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# NITROGEN

THE MAGAZINE OF WORLD NITROGEN

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# MORE FERTILISER FOR INDIA

Simon-Carves have received a contract from East India Distillers & Sugar Factories Ltd
to build a complete new compound fertiliser factory in Ennore near Madras.
The contract includes the design and supply of the equipment,
the civil engineering work and the erection and commissioning of the plant.
The factory is to come into production in two years time.
Approximately 51,000 tons a year of compound fertilisers based on ammonium phosphate
will be produced, but in addition to the fertiliser plant the factory will house
sulphuric and phosphoric acid plants, an ammonia synthesis plant
and raw material and product storage and handling equipment.

**COMPLETE FERTILISER PLANTS BY** *Simon-Carves Ltd*

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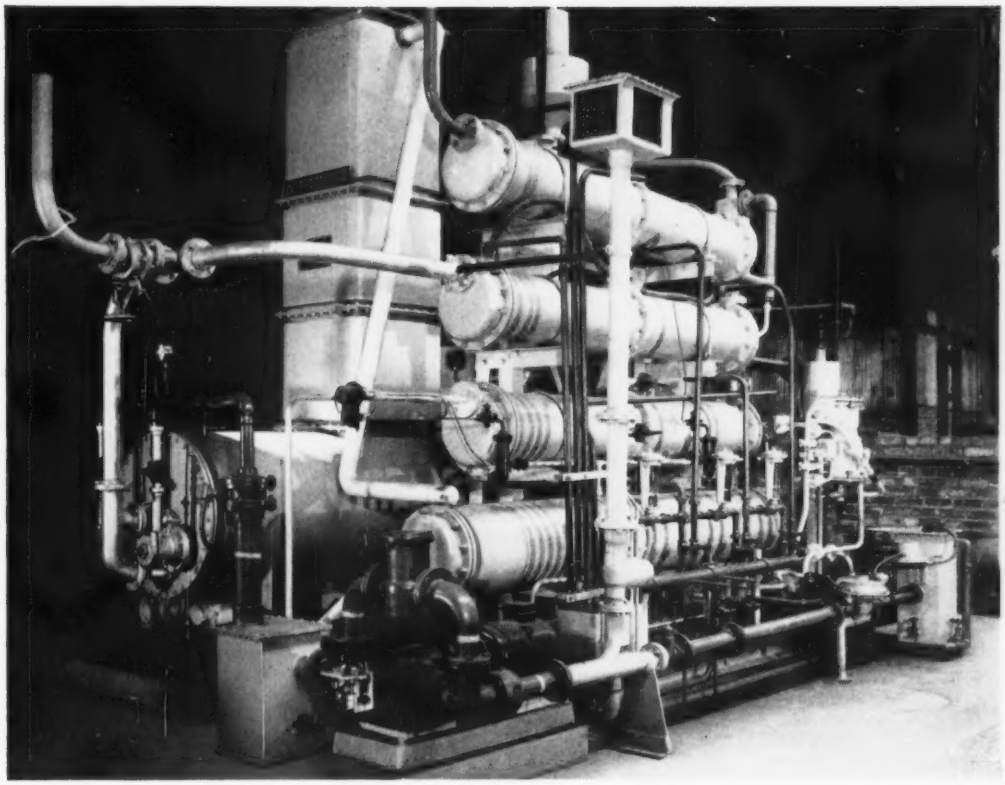
and at CALCUTTA . JOHANNESBURG . SYDNEY . TORONTO



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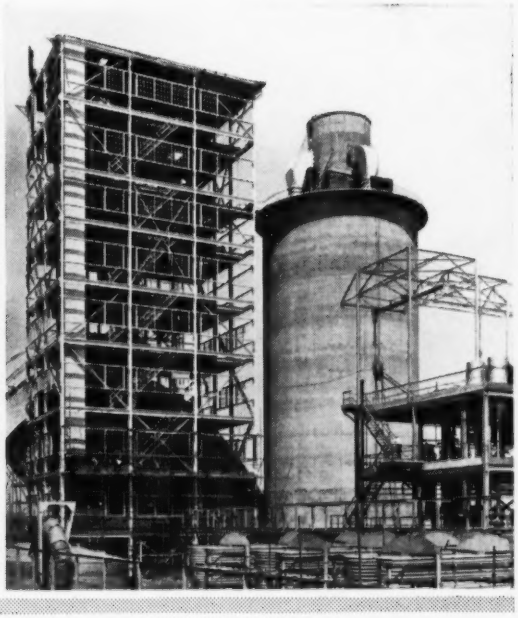
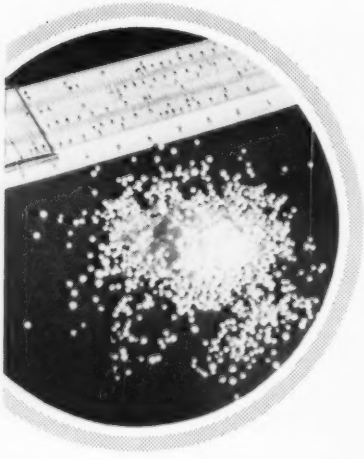
*Urea plant at Modderfontein, South Africa, during erecting*



# 300 tons of Urea per day



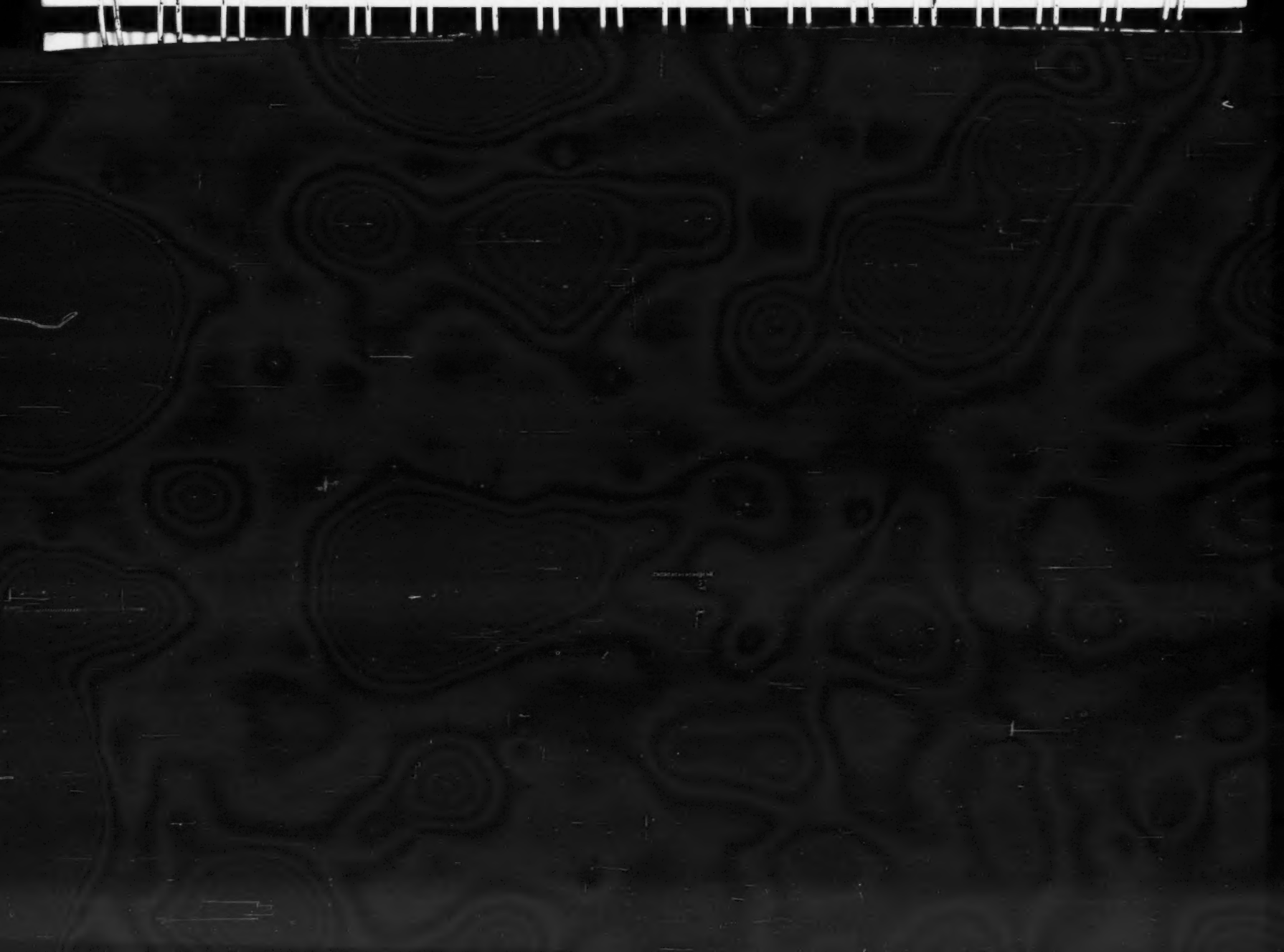
This high capacity Urea plant is constructed and erected by Werkspoor to the designs of Stamicarbon-Holland. Werkspoor is fully qualified to supply the following plants:

1. Ammonia synthesis (starting from liquid or gaseous fuels)
2. Nitric acid (starting from ammonia)
3. Nitrolimestone (starting from nitric acid, ammonia and limestone)
4. Nitrophosphate (starting from raw phosphate, nitric acid and ammonia)
5. Calcium nitrate (starting from limestone and nitric acid)
6. Sulphate of ammonium (starting from ammonia and sulphuric acid)
7. Urea (starting from liquid ammonia and carbon dioxide)

**WERKSPOOR**

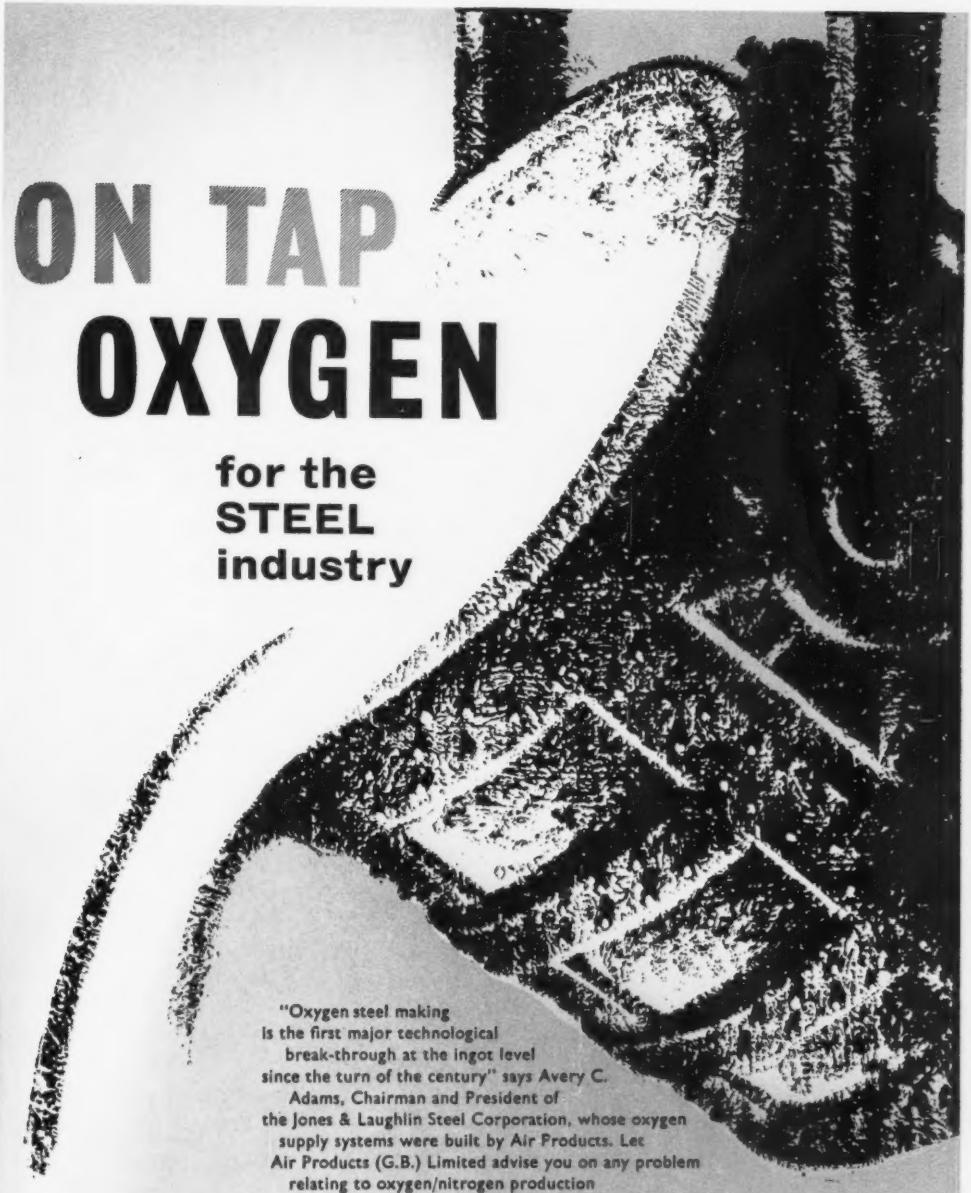
WORKS AT AMSTERDAM AND UTRECHT

Beuduin



# ON TAP OXYGEN

## for the STEEL industry



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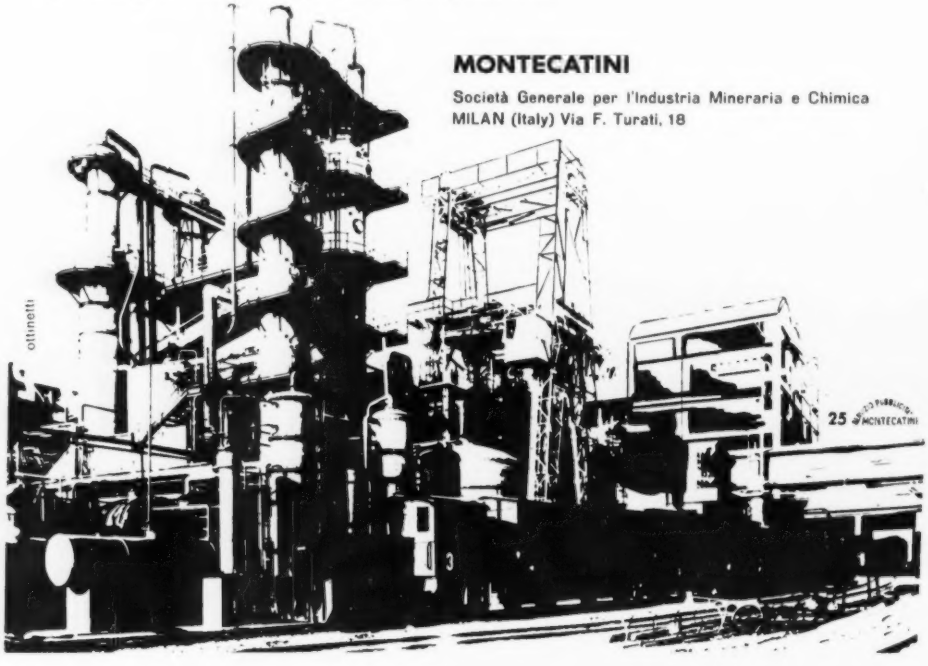


**MONTECATINI**

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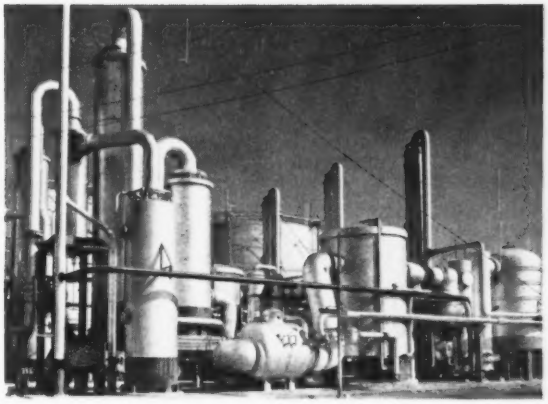
# Italy Now the Sixth Largest Producer of Nitrogen in the World



**Plant for processing methane for nitrogen production at Montecatini's Ferrara plant**

SIXTH LARGEST producer of nitrogen in the world—surpassed only by the U.S.A., West Germany, Japan, U.S.S.R. and France—Italy in 1959-60 produced 667,000 tonnes N and it is estimated that installed capacity is at present 750,000 tonnes N. Her domestic markets represent an outlet for about 425,000 tonnes industrial and fertilizer nitrogen whereas exports in the fertilizer year ending June 1960 totalled 264,000 tonnes.

## Economic Background

Last year industrial production in Italy rose no less than 16% over that of 1958 when, in contrast with many other industrialised countries, it had maintained its momentum of growth. The remarkable expansion of Italy's nitrogen industry — production rose 50% between 1957 and 1959—reflects the growth record of Italy's whole economy. During the earlier part of this year boom conditions continued in Italy and the nitrogen industry fully shared in this. Industrial production in the first quarter was 17% higher than in the corresponding period of 1959, a wide variety of industries setting one production record after another, and exports from January to May were over 40% higher than last year.

The remarkable increase of exports has narrowed the trade gap and receipts on invisibles and inflow of capital produced an increase of nearly 50% in the gold and foreign currency reserves over the three years from just over $2,000 million to almost $3,000 million. Particularly noticeable has been the stable price level and the decline in unemployment.

Northern Italy is now suffering from a labour shortage and some surplus labour from the south has migrated to the north. The south, where the Government promotes investment projects under the Cassa di Mezzogiorno, has been making quite marked progress, but the gap in wealth and productivity between the north and the south goes on widening. Within this overall picture Italy's chemical industry plays a notable part. It has one of the world's highest growth rates—a 50% increase since 1955—culminating in a 16½% rise in 1959. This compares with the growth rate of the U.S. chemical industry which since 1955 has been 20% overall or under 5% a year.

**Index of Italian Chemical Production**

| 1953 | 1956 | 1957 | 1958 | 1959 |
|---|---|---|---|---|
| 100 | 148 | 154 | 175 | 209 |

Italian chemical exports for 1959 were valued at 138,000 million lire (£79 million), 26% more than in 1958. The increase in exports was mainly due to chemical fertilizers, which increased by 41%.

The Italian chemical industry has gone ahead not because of a favourable raw materials position, which is limited to natural gas deposits in northern Italy and those recently discovered in the south, petroleum in Sicily and the questionable advantage of indigenous sulphur, but primarily because of the remarkable general technical level and original ideas, particularly in the plastics and nitrogen sectors.

### Italian Nitrogen Technology

To-day 35% of the world's nitrogen capacity in several hundred plants is based on the Italian Fauser-Montecatini or Casale ammonia processes. Montecatini's urea process has made a major contribution towards reducing the cost of nitrogen in urea to the level of nitrogen in other lower concentration materials and to-day 34 urea plants in the world are based on it.

The plastics industry in Italy is among the most prominent in recent years and nitrogen finds wide usage in it, being used in urea and melamine resins.

The leading chemical manufacturer, Società Montecatini, has a programme under way at the present time, whereby it is planned to double production within the next three to five years. It includes a £70 million petrochemical plant at Brindisi now under construction, which may have chemical fertilizer plants associated with it. Also getting under way in the south amongst major industrial projects is a new steel plant at Taranto and a large new petroleum chemical centre of Ente Nazionale Idrocarburi (E.N.I) in east Sicily.

### Fertilizer Usage

Despite Italy's industrial expansion the greater part of her population is engaged in agriculture. The optimum provision of plant food, therefore, assumes a great importance. Up to date, however, no clear trend has emerged and the Italian farmer uses straight N and P fertilizers—as yet relatively small amounts with high analysis — binary and ternary mixtures, and more recently an increasing volume of complex materials. Producers' main emphasis has been on stimulating the volume of consumption under increasingly competitive conditions. This has resulted during the last few years in a continued fall of fertilizer prices—nitrogenous and complex fertilizers in particular—until they now barely cover production costs. Indeed, the recently reduced prices of chemical fertilizers by the Italian Government have alarmed producers of whom Soc. Montecatini are the largest. This company's president, Count Carlo Faina, stated in September that he did not feel that new processes used in the production of chemical fertilizers permitted the severe cuts in prices of Italian chemical fertilizers which were the lowest in the world—an opinion shared by the Italian Chemical Industry Association. In the latter's view Italian fertilizer manufacturers have already made enough sacrifices during the past years and if the Italian farming community required help this should be given by means of Government grants or subsidies, not just by the fertilizer producers.

## PRODUCTION

Production of nitrogen in Italy during the year ending 30 June 1960 totalled 667,000 tonnes N. Of total output 94½% was represented by synthetic ammonia, 1½% by by-product ammonia and the balance by N in calcium cyanamide, the production of which declined sharply in the past year. The expansion of Italy's nitrogen industry is clearly reflected by synthetic ammonia production, which has shown remarkable strides. Totalling some 533,307 tonnes in 1957-58, production rose by 10.4% to 694,171 tonnes in the following year, and in the fertilizer year 1959-60 even more sharply to reach 763,829 tonnes, an increase of 35.8%.

Over the past three years Italian production of N fertilizers (including complexes) has continued to expand. Totalling 409,000 tonnes N in 1957-58, production rose steeply by 30% in 1958-59 to 531,000 tonnes and to 590,000

**Italian Consumption of Fertilizers**
**(Tons)**

| Periods | Fertilizers | + − % | Fertilizing elements N | + − % | $P_2O_5$ | + − % | $K_2O$ | + − % | Total | + − % | $N:P_2O_5:K_2O$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951-52 ... | 2,533,660 | — | 161,347 | — | 296,291 | — | 25,774 | — | 483,412 | — | 1:1.9:0.16 |
| 1952-53 ... | 2,858,460 | +13 | 181,346 | +12.4 | 341,738 | +15.3 | 34,856 | +35.2 | 557,940 | +15 | 1:1.9:0.18 |
| 1953-54 ... | 3,281,080 | +14 | 210,054 | +15.8 | 397,344 | +16.3 | 37,692 | + 8.1 | 645,090 | +15 | 1:1.9:0.18 |
| 1954-55 ... | 3,560,808 | + 9 | 237,895 | +13.3 | 424,558 | + 6.8 | 46,572 | +23.6 | 709,025 | + 9 | 1:1.8:0.16 |
| 1955-56 ... | 3,612,001 | + 1 | 253,875 | + 6.7 | 421,549 | − 0.7 | 56,986 | +22.4 | 732,410 | + 3 | 1:1.6:0.20 |
| 1956-57 ... | 3,615,718 | — | 273,920 | + 7.9 | 399,768 | − 5.2 | 59,945 | + 5.2 | 733,633 | — | 1:1.4:0.20 |
| 1957-58 ... | 3,469,417 | − 4.4 | 268,660 | − 2.0 | 385,828 | − 3.5 | 69,352 | +15.0 | 723,840 | − 1.5 | 1:1.4:0.25 |
| 1958-59 ... | 3,562,741 | + 2.5 | *298,327 | +11.0 | †382,079 | − 1.0 | ‡79,205 | +14.9 | 759,611 | + 4.9 | 1:1.3:0.25 |

* of which 16% about from compound fertilizers
† of which 24% about from compound fertilizers
‡ of which 45% about from compound fertilizers

the year 1959-60—the highest production yet reached in Italy. It is estimated that Italian production of industrial nitrogen, including nitric acid used for non-fertilizer purposes, is currently 75,000 tonnes N, out of which Società Montecatini is estimated to account for 85%.

## Natural Gas for $NH_3$ Syntheses

More than one-half of Italian ammonia production is based on natural gas, which as a source of hydrogen has assumed increasing importance in the past 10 years as all new installations operate on this basis. Correspondingly, the share of coke oven gas has declined, although there has been no significant change in the plant capacity dependent on this source.

The remarkable increase of the proportion of ammonia manufactured from natural gas is attributable as much to its virtually exclusive use at new plant, as to the progressive changeover in some of the older Montecatini plants. This company appears to have abandoned entirely the manufacture of electrolytic hydrogen notably at the large plant at Merano and the use of coke oven gas has been reduced at some works.

**Raw Materials of Italian Ammonia Production**

| | Methane | Coke Oven Gas: Generator Gas | Coke Oven Gas: Electrolysis | Refinery Gas & Fuel Oil |
|---|---|---|---|---|
| | % | % | % | % |
| 1952 ... | 4.20 | 11.77 | 68.83 | 20.20 |
| 1953 ... | 20.64 | 16.48 | 45.63 | 17.24 |
| 1954 ... | 29.66 | 15.62 | 40.38 | 14.34 |
| 1955 ... | 39.46 | 10.43 | 38.34 | 11.77 |
| 1956 ... | 44.39 | 9.12 | 37.46 | 9.03 |
| 1957 ... | 42.94 | 8.63 | 40.45 | 7.98 |
| 1960 ... | 68.00 | — | 26.00 | 1.00 5 |

The bulk of N fertilizer production in Italy is represented by ammonium sulphate, ammonium nitrates (20.5% N, 26.5% N and 35% N), calcium and sodium nitrates (14% N and 15.5% N), urea and calcium cyanamide. Phosphonitrates and ammoniated superphosphates play a large part but since the last fertilizer year complex fertilizers, including ammonium phosphates, have become more prominent.

Ammonium sulphate remains the most important N fertilizer and in 1959-60 1,224,187 tonnes were produced, a 12.4 increase on the previous fertilizer year and representing 38.4% of total N production. Of the three grades of ammonium nitrates produced in Italy, calcium ammonium nitrate (20.5% N) output of 673,256 tonnes is the most prominent; it also showed

**N Fertilizer Production**

(tonnes)

| | 1957/58 | 1958/59 | | 1959/60 | |
|---|---|---|---|---|---|
| **Ammonium Sulphate** | 780,775 | 1,089,086 | +39.4% | 1,224,187 | +12.4% |
| **Ammonium Nitrate** (20.5% N) | 413,094 | 597,343 | +44.6% | 673,256 | +12.7% |
| (26.5% N) | 21,168 | 59,359 | +179.5% | 25,248 | −57.4% |
| (35% N) | 10,722 | 11,519 | +7.4% | 12,195 | +5.8% |
| **Calcium Nitrate** (14% N) | 8,257 | 3,566 | −56.8% | 2,784 | −22.3% |
| (15.5% N) | 299,651 | 313,364 | +4.5% | 322,987 | +3.1% |
| **Sodium Nitrate** (15-16% N) | 6,551 | 6,511 | −0.6% | 6,882 | +5.7% |
| **Calcium Cyanamide** (20.5% N) | 165,139 | 182,816 | +10.7% | 133,465 | −27.0% |
| **Urea** (45% N) | 34,717 | 70,618 | 103.5% | 78,646 | +11.4% |
| **Ammonium Superphosphates** | 84,163 | 120,509 | +43.2% | 169,242 | +40.5% |
| **Phospho Nitrates** | 139,807 | 179,660 | +28.5% | 180,997 | +0.13% |
| **Complexes** | 289,183 | 391,738 | 35.4% | 771,617 | +97.0% |

the largest growth, accounting for over 90% of all N fertilizers. Ammonium nitrate (35% N) output increased only moderately (5.8%), whereas production of the 26.5% N grade declined sharply (−57.4%). Significantly, calcium cyanamide output also declined (−27%) to 133,465 tonnes, but Italy is still the fourth largest producer in the world.

Urea production — after more than doubling in the preceding year to 70,618 tonnes—continued to mount at a more modest rate (11.4%) and in 1959-60 totalled 78,646 tonnes.

### Urea Production

Production of ammoniated superphosphate has continued to increase. From the 84,163 tonnes produced in 1957-58, and 120,509 tonnes in 1958-59, output has risen to 169,242 tonnes, a 40.5% increase. Similarly, phosphonitrates production rose to over 200,000 tonnes, an increase of over 25%; potassium nitrate production started in 1959 and complex fertilizers assumed significant proportions.

Installed capacity in Italy for ammonia and calcium cyanamide production is estimated at 750,000 tonnes N. All major installations have considerable flexibility in their capacity for producing different types of nitrogenous fertilizers. The largest proportionate increase in the past three years is in urea capacity, which now totals 180,000 tonnes a year, of which Soc. Montecatini has nearly 72%.

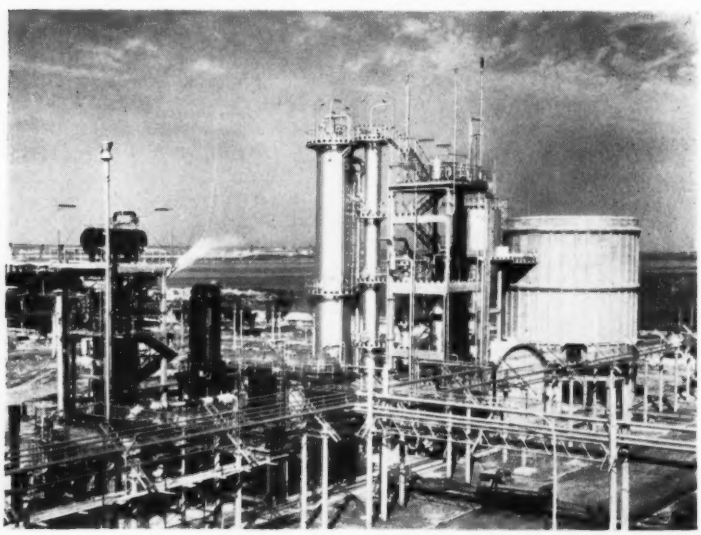
## PRODUCERS

Italy's nitrogen industry is represented by six producers, of which two are individual companies—the others are groups with one or more associated companies. The largest and most important is Soc. Montecatini with installed capacity estimated at 403,000 tonnes N, of which the works of Cokitalia and Cokapuania account for 100,000 tonnes.

Competition in the Italian nitrogen market sharpened in 1958 with the entry of A.N.I.C., a subsidiary of E.N.I. (Ente Nazionale Idrocarburi) a part-Governmental organisation. In view of E.N.I. the control of the natural gas supplies, private industry and Montecatini in particular raised strong objection when A.N.I.C. established a major N plant at Ravenna and questioned the equity of the natural gas prices as well as the entry of Government finance into what had hitherto been an exclusively private sector of Italian industry.

### Soc. Montecatini

Soc. Montecatini operates ten synthetic ammonia plants; these are at Novara, Mas, San Giuseppe di Cairo, Merano, Crotone, Apuania, Tarquinia, Ferrara Napoli, Priolo and Porto



**Gas-cracking plant at Augusta Petrolchemica's Priolo plant for fertilizer production**

**Montecatini Plants Producing Nitrogenous Fertilizers**

| Fertilizer | Production facilities at | |
|---|---|---|
| **Ammonium Sulphate** ... ... | Cripuania | Novara |
| | Crotone | Porto Marghera |
| | Merano | San Giussepe de Cairo |
| | Napoli | |
| **Ammonium Nitrate** ... ... ... | Apuania | Novara |
| | Ferrara | Porto Marghera |
| **Urea** ... ... ... ... ... | Ferrara | San Giuseppe di Cairo |
| | Novara | |
| **Calcium Nitrate** ... ... ... | Crotone | Porto Marghera |
| | Merano | San Giuseppe di Cairo |
| **Nitric Acid** ... ... ... ... | Apuania | Novara |
| | Crotone | Porto Marghera |
| | Ferrara | San Giuseppe di Cairo |
| | Merano | |
| **Complex Fertilizers** ... ... ... | Castel Fiorentino | Montemarciano |
| | Castelguelfo | Orbetello |
| | Crotone | Porto Epedocle |
| | Legnano | Porto Marghera |
| | Barletta | Vercelli |

Marghera which produce all types of nitrogen fertilizers and 70% of Italy's industrial nitrogen including nitric acid.

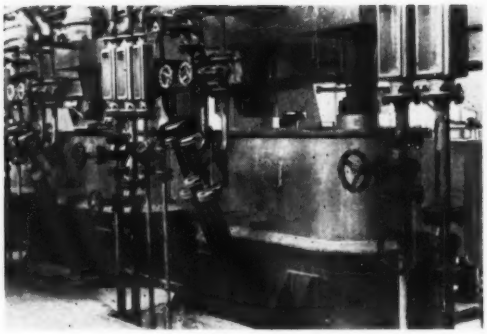
*Ferrara.* The nitrogen works at Ferrara, the most modern of Montecatini's large nitrogen facilities, came on stream in 1953. The main nitrogen product is ammonia, based on natural gas as the feedstock and the Fauser-Montecatini process. Potential production capacity is stated to be 90,000 tonnes N a year.

In designing the nitrogen works at Ferrara, Montecatini aimed at a plant with a large volume capacity, and highly automated so that it would be capable of producing finished products of better quality and of despatching them quickly. At Ferrara 75,000 tonnes N. anhydrous ammonia, 18,000 tonnes N of nitric acid, 46,000 tonnes ammonium nitrate and 13,500 tonnes N of urea can be produced annually. In its choice of Ferrara as a nitrogen producing centre the company was influenced by the availability of modern and well equipped dock facilities, with outlets through the navigable canals which meet the Po and the Adriatic coast, and a good local market in the rich agricultural area nearby.

*Novara.* The first of Montecatini's nitrogen plants, the Novara nitrogen works, came on stream in 1924 when it had a capacity of only 10,000 tonnes N synthetic ammonia with installations for ammonium sulphate (3,000 tonnes N), ammonium nitrate (2,000 tonnes N) and nitric acid (3,400 tonnes N). In 1953 the plant was considerably modernised and expanded and to-day it is based on water gas, electrolysis and natural gas as a source of hydrogen for synthesis of ammonia. Anhydrous ammonia capacity is now 75,000 tonnes N, ammonium nitrate plant capacity has been expanded to 15,000 tonnes and urea capicity to 13,500 tonnes N, the largest in the Montecatini group. Urea production was first started at Novara in 1935 when 810 tonnes N were produced.

### Cokitalia and Cokapuania

The two subsidiaries of Montecatini, Cokitalia and Cokapuania, together produce about 100,000 tonnes N annually. The Cokitalia plant, situated at S. Giuseppi di Cairo, started production in 1936. To-day, using coke oven gas and refinery gases, 68,000 tonnes N of anhydrous ammonia is produced, and there are also facilities for producing nitric acid (17,000 tonnes N), ammonium sulphate (44,500 tonnes N), ammonium nitrate (11,000 tonnes N), calcium nitrate (1,000 tonnes N) and urea (3,000 tonnes N). Urea has been produced at this plant since 1939. Cokapuania's nitrogen works at Apuania produce anhydrous ammonia (20,000 tonnes N), and nitric acid (4,000 tonnes N), ammonium sulphate (7,500 tonnes) and ammonium nitrate (9,000 tonnes N) and started in 1940. In 1953, calcium nitrate (15,500 tonnes N) was added to the nitrogen fertilizer range. Feedstock for this works is coke oven gas and methane.



**Detail of a reactor used in the PEC process for complex fertilizer at A.N.I.C. plant, Ravenna, Italy**

### Augusta Petrolchemica

At Priolo (Syracuse) in Sicily, the associated company of Montecatini, Augusta Petrolchemica, operates a modern synthetic ammonia plant with an annual capacity of 33,000 tonnes N. Highly automated, the Priolo installations came on stream in 1958 and are based on refinery gas from the nearby refinery. Augusta Petrolchemica's plants are linked to the refinery pipeline and two gas conduits; additional hydrogen is obtained from light benzol. The company's output is destined for other establishments of the Montecatini group for production of simple and complex fertilizers. The plant includes large liquid ammonia storage facilities, Horton Spheres; each of 150 cubic metres capacity and a combined capacity of 2,000 tonnes ammonia.

In processing the refinery gas, compressors are being used which are powered with residual fuel gases instead of electrical energy.

Included in the Montecatini group is Akragas of Porto Empedocle — this company's nitrogen plant began production in 1954 — and Vetrocoke, Milan, which Montecatini acquired within the last two months. Vetrocoke produces nitrogen as by-product from coke ovens.

On the production side new developments by Soc. Montecatini include the following: At the Porto Marghera works of Vetrocoke (now wholly owned by Soc. Montecatini) erection of a urea plant has reached an advanced stage; in this same area a large diammonium phosphate plant will soon be in operation; work has also begun on the expansion of the compound fertilizer factory at Porto Empedocle, Agrigento.

### E.N.I. - A.N.I.C.

*Ravenna.* This state-owned corporation controls the supply and sales of natural gas resources of the Po valley. Through its control of A.G.I.P. which produces, refines and markets petroleum products and which has a majority interest in A.N.I.C. whose N plant at Ravenna is now the largest in Italy, E.N.I. has come to play a major part in Italy's nitrogen industry. The Ravenna plant came on stream in 1958 to produce from natural gas S-BR rubber and nitrogenous fertilizers. Methane is broken down to acetylene which is used to make acetaldehyde and other petrochemicals. The large quantities of hydrogen and carbon monoxide released by this process are used with atmospheric nitrogen for the production of over 20 tons an hour of synthetic ammonia. Ammonia capacity is 150,000 tonnes N and Casale process is employed. Some of the ammonia is converted to nitric acid in a plant with an annual capacity of 22,000 tonnes N based on the Udhe process. Ammonium sulphate manufacture is based on the I.C.I. gypsum process whereby locally mined gypsum is reacted with ammonium carbonate produced with ammonia, carbon dioxide and water. Plant capacity is 400,000 tonnes ammonium sulphate and 100,000 tonnes calcium nitrate is manufactured as co-product. A prilled lime ammonium nitrate plant has an annual capacity of 220,000 tonnes and there is a 50,000 tonnes Stamicarbon urea plant. Complex fertilizer capacity is 80,000 tonnes annually of (9 - 18 - K) fertilizer. Approximately 40% of total capacity—60,000 tonnes N — is intended to serve the domestic market. E.N.I.'s major project for an oil refinery and petrochemical complex at Gela embodies nitrogen fertilizer production facilities which are expected to include a plant for the manufacture of ammonium sulphate (15,000 tonnes N) and urea (60,000 tonnes N). The refinery will work on crude oil obtained from local deposits at Gela and ammonia manufacture is based on refinery gases.

### Sarda Ammonia

One of Italy's older nitrogen plants is that of Sarda Ammonia at Coghinas in

Sardinia. The plant which was started in 1927 has an annual ammonia capacity of 5,000 tonnes N from which mainly ammonium sulphate is manufactured. Hydrogen for ammonia production is produced by electrolysis and ammonia synthesis is by the Montecatini process.

### Societa Edison

At the company's Porto Marghera plant ammonia production is based on natural gas and installed capacity is 70,000 tonnes N. Ammonium sulphate, ammonium nitrate, complex fertilizer and nitric acid are the main products and there are also facilities for calcium cyanamide manufacture. The plant came into operation in 1958 and uses the Casale process for synthetic ammonia production. Annual capacity is now 1,500,000 tonnes of synthetic nitrogenous fertilizers. During 1959, the company brought on stream a new plant at Porto Marghera for the production of hydrocyanic acid and the increased output has allowed expansion of acrylonitrile production.

### Sincat

A member of the Società Edison group, the Società Industriale Catanese (SINCAT) operates a synthetic ammonia plant and a complex fertilizer plant at Priolo, Sicily. The complex fertilizer plant came on stream in December 1955 and the ammonia plant in 1958. The latter uses the Texaco process. Feedstocks for the Priolo plants are natural gas or crude oil. Production is intended to cover the greater part of the nitrogenous fertilizer requirements of Sicily and Southern Italy and to allow considerable exports to the rest of the Mediterranean area.

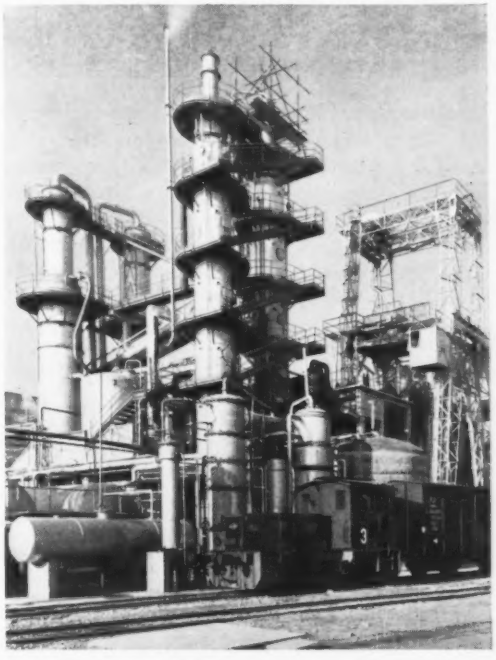
### Soc. Terni

The company operates a number of synthetic nitrogen plants Nera Montero. Production of synthetic ammonia annually is about 30,000 tonnes N and is converted to ammonium sulphate (15,000 tonnes N). Calcium nitrate (15,000 tonnes N) and calcium cyanamide is also produced.

Last year, Soc. Terni's plants produced 32,000 tonnes of ammonia, 9% less than in 1958. Calcium nitrate production of 90,000 tonnes was 2% higher than in 1958 and ammonia sulphate production of 43,000 tonnes 27% higher. Sales of calcium cyanamide declined 6%.

## EXPORTS

Italy only became established as a major exporter of nitrogenous fertilizers during the past ten years. Prior to World War II her exports fluctuated widely but rarely exceeded a few thousands tons N. During the five years up to 1958 Italy's exports of fertilizer nitrogen rose steeply from 50,000 tonnes N to 170,000 tonnes N and in 1959/60 they totalled 255,000 tonnes. The entry of A.N.I.C. into Italy's fertilizer industry in 1958 resulted in Soc. Montecatini losing a large share of its domestic fertilizer nitrogen market and in consequence, greater emphasis on exports by Soc. Montecatini and associated companies. These as well as all other Italian N fertilizer producers with the exception of A.N.I.C. who market independently, export through SEIFA. Approximately one-half of Italy's exports are directed to Asia and European importers, notably Spain, Greece and Yugoslavia account



**Urea production using selective separation at Montecatini's Ferrara plant**

for at least a third. Egypt remains another one of Italy's major markets.

In the past year the pattern of supply has changed substantially. Whereas in 1958 ammonium sulphate accounted for only 37% of total exports and ammonium nitrate for 49% and urea for 14%, the heavy increase of deliveries to China coupled with sales of ammonium sulphate to Spain resulted in the following changes in Italy's export pattern in 1959/60.

### Ammonium Sulphate

Of Italy's total ammonium sulphate exports of 662,823 tonnes China and Spain accounted for 60%. Exports of this fertilizer show the largest increase compared with any other country, having risen by 65% in the past two years.

| | 1957/58 | 1958/59 | 1959/60 |
|---|---|---|---|
| Greece ... ... | 61.8 | 82 | 66.8 |
| Portugal ... ... | 15.9 | — | — |
| Spain ... ... | — | — | 158.1 |
| Turkey ... ... | 21.3 | 53.7 | — |
| China ... ... | 95.2 | 151.3 | 290.2 |
| India ... ... | 3.4 | 19.3 | 64.7 |
| Indonesia ... ... | — | 10.3 | — |
| South Korea ... | 61.8 | 30.0 | n.a. |
| Pakistan ... ... | 34.1 | 9.6 | 21.6 |
| Others ... ... | 5.3 | 40.6 | 61.4 |
| **TOTAL ...** | **298.8** | **396.8** | **662.8** |

### Ammonium Nitrate

Egypt has continued to be the main market for ammonium nitrate fertilizer, taking 103,234 tonnes in 1959/60, with China the next largest with 99,719 tonnes. Sales of this fertilizer to China have increased although not as markedly as those of ammonium sulphate. Bulgaria, Greece and Yugoslavia have also taken notable quantities of this fertilizer, but rising domestic production in Yugoslavia is progressively narrowing this market.

| | 1957/58 | 1958/59 | 1959/60 |
|---|---|---|---|
| Yugoslavia ... | 76.5 | 81.5 | 41.8 |
| Greece ... ... | 5.0 | 35.1 | 58.2 |
| Bulgaria ... ... | — | 31.9 | 59.8 |
| Egypt ... ... | 23.8 | 117.6 | 103.2 |
| China ... ... | 26.6 | 81.9 | 99.7 |
| Others ... ... | 43.0 | 27.2 | 56.2 |
| **TOTAL ...** | **174.9** | **375.2** | **418.9** |

### Urea

Of Italy's total urea production in 1959/60 of 78,646 tonnes about 67% was exported. During the last three years China has been a growing market for this nitrogenous fertilizer as has been the Sudan. The small sales in West Europe, India and South America were not maintained.

| | 1957/58 | 1958/59 | 1959/60 |
|---|---|---|---|
| France ... ... | 950 | 20 | — |
| Portugal ... ... | 294 | 120 | — |
| China ... ... | 15,223 | 20,796 | 28,261 |
| India ... ... | 27,356 | 20,020 | 3,500 |
| Sudan ... ... | — | 10,639 | 19,594 |
| Philippines ... ... | — | 454 | — |
| Taiwan ... ... | 876 | 519 | — |
| Brazil ... ... | 1,643 | 506 | — |
| Colombia ... ... | 3,320 | 147 | — |
| **TOTAL ...** | **50,008** | **56,114** | **53,698** |

### Calcium Nitrate

Exports of calcium nitrate from Italy of 16,881 tonnes have increased fourfold compared with 1958/59, but the export destinations have changed noticeably. Austria was the largest market in 1958/59, but disappeared completely in 1959/60. Spain, not previously an outlet, took 5,540 tonnes, and was Italy's largest market for this fertilizer. Yugoslavia imported 1,238 tonnes last year but Portugal ceased as a market outlet for calcium nitrate.

## DOMESTIC MARKET AND PRICES

In the past 18 months the rapid expansion of N fertilizer capacity has been accompanied by a significant decline in prices. These are determined by the Government but competition at first in complex materials and later in all nitrogenous fertilizers has been such, that effective sale prices were well below permitted levels — often by as much at 30%. The entry of E.N.I. as a major producer of nitrogenous fertilizer accentuated competition, but the major controversy centered on E.N.I.'s control of natural gas supplies. As natural gas accounts for over one-half of Italy's ammonia production, the activities of E.N.I. gave rise to much anxiety amongst private enterprises, notably the Montecatini and Edison groups. The view has been put forward that E.N.I. were determining the price of gas at a higher level for their competitors than sold to its own subsidiary A.N.I.C.

Sr. Enrico Mattei, president of E.N.I., however, denied in 1958 that E.N.I. would exploit their resources to the detriment of private producers, stating he would rely on the efficiency of his plant at Ravenna.

In this connection it is perhaps relevant that Montecatini, Italy's largest producer, bases

only 50.5% of ammonia production on natural gas, whereas the Ravenna plant obtains its hydrogen wholly from the natural gas based synthetic rubber plant.

Whether E.N.I. have exploited their favourable position over the last two years seems undecided, but the fact remains that to-day the prices of chemical fertilizers in Italy is about 20% or 25% lower than they were before the advent of E.N.I. and the present prices of nitrogen fertilizers are stated by the industry to be the lowest that costs will permit. The Italian Minister of Agriculture and Forestry in a recent statement quoted figures showing the comparative domestic consumers prices of the main nitrogenous fertilizers in the leading fertilizer manufacturing countries:—

**Prices to Consumers**
(in terms of N content)

| | lire/tonne N | Converted price £ s. |
|---|---|---|
| **Ammonium Sulphate** | | |
| Italy ... ... | 152,680 | 87 10 |
| Netherlands ... | 166,698 | 95 10 |
| United Kingdom ... | 173,250 | 99 0 |
| Luxembourg ... | 178,560 | 102 0 |
| Belgium ... ... | 182,460 | 104 10 |
| Germany ... ... | 182,890 | 104 10 |
| France ... ... | 192,310 | 110 0 |
| Portugal ... ... | 208,640 | 119 10 |
| Spain ... ... | 223,210 | 127 10 |
| **Ammonium Nitrate** | | |
| Italy ... ... ... | 131,700 | 75 10 |
| Netherlands ... | 164,190 | 98 0 |
| Luxembourg ... | 172,400 | 98 10 |
| Belgium ... ... | 184,190 | 105 10 |
| France ... ... | 187,060 | 107 0 |
| Germany ... ... | 187,180 | 107 0 |
| Portugal ... ... | 196,029 | 112 0 |
| United Kingdom ... | 203,540 | 116 10 |
| Spain ... ... | 241,950 | 138 10 |

The following is a comparison with prices in Communist countries in 1958/59:—

| | | |
|---|---|---|
| Italy ... ... ... | 175,220 | lire/tonne |
| Hungary ... ... ... | 258,500 | ,, ,, |
| Czechoslavakia ... ... | 266,777 | ,, ,, |

The new prices of chemical fertilizers in in Italy represent a saving to Italian farmers of about 10 thousand million lire a year (£57.3 million).

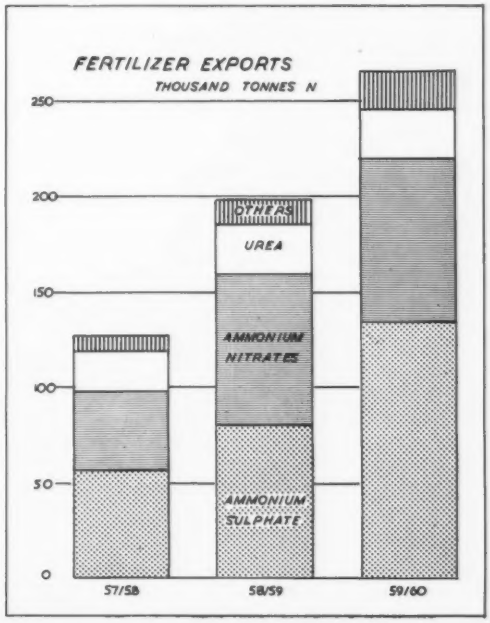
Government and producers now hope that low prices will encourage the farmer to increase consumption, although compared with other countries of Western Europe, Italy's fertilizer usage is not excessively low.

| Country | N/Hectare |
|---|---|
| West Germany ... ... ... | 40 |
| Belgium ... ... ... ... | 56 |
| Netherlands ... ... ... ... | 90 |
| Italy ... ... ... ... ... | 21 |
| Greece ... ... ... ... | 19 |
| Spain ... ... ... ... | 11 |
| France ... ... ... ... | 17 |

It must be borne in mind, however, that many other factors have had a restrictive effect on the level of Italian fertilizer use and consumption is not expected to rise very much, even with the low prices now prevailing.

## OUTLOOK

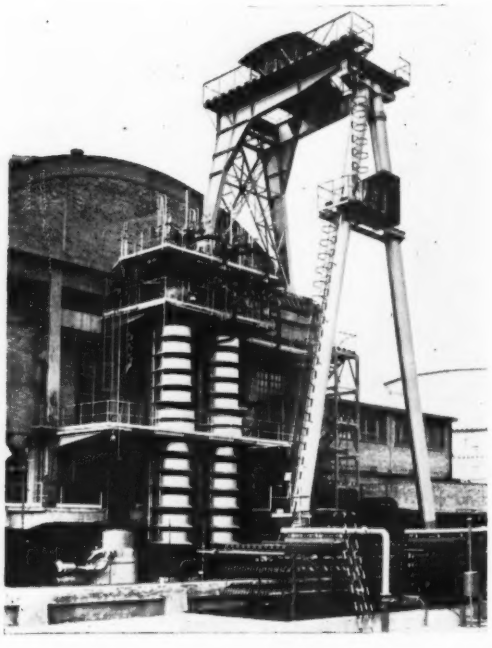
Italy's nitrogen industry is in a strong position when viewed from the technological and plant aspects. Process know-how is far advanced as is indicated by the world-wide licensing arrangements for Fauser, Montecatini and Casale processes. In recent years, too, the larger nitrogen-producing works have been modernised, re-equipped and expanded to an extent that installed capacity is substantially in excess of domestic demand and more than adequate to meet the level of exports as well. Italy's nitrogen industry has the benefit of varied and ample sources of raw materials but especially of methane in natural gas, use of which meets over 3/5th of current ammonia output and which offers economic conditions of production. This is not taking into account any new sources of natural gas or oil which are actively being sought by Government agencies in Italy and offshore and also abroad



through concessions in Sudan, the Sahara, Morocco, Tunisia and Iran.

The expansion of Italy's nitrogen industry during the past 5 years has been part of a great industrial boom. Casting a shadow is the question of what will happen particularly in the South if the pace of expansion in the North slackens and there are indications that boom conditions are slowing down. Italy's success in the export markets makes her economy vulnerable to any recessionary trends in world trade although it is considered any ill effects will be limited as long as Western Europe and the Common Market remain prosperous, while Italy's present reserves can stand up to a deterioration in her trade balance.

To the nitrogen fertilizer industry the progressive reduction of prices especially on the home market is a matter of some concern. Competition between private enterprise is welcomed but the industry cannot reconcile itself to the Government influence through the operations of E.N.I., nor is it acceptable that nitrogenous fertilizers should be made available domestically at prices which come near to subsidising the Italian farmer. The remedy undoubtedly lies in the expansion of domestic fertilizer demand, which for a country with as predominant an agriculture as Italy's is relatively low. Price alone has not proved to be the major factor encouraging use of nitrogenous fertilizers and experience indicates that considerable education of the farmers is required and that this education should be continuous and come not only from the Government but from the producing companies themselves.



**Column for synthesis of ammonia. Augusta Petrolchemica Priolo plant**

It is significant that were the Italian farmer to raise his use of nitrogen to the average rate of that in the Common Market countries, domestic consumption would be double to a total of over 700,000 tonnes N.

Industrial nitrogen demand which has risen steadily to the current level of about 75,000 tonnes, can be expected to exceed 100,000 tonnes N by 1965. In recent year's Italy's N fertilizer industry has made great strides in gaining export markets and in 1959/60 Italy exported more than 40% of her production, the main markets being China, Spain, Greece, Egypt and Yugoslavia. From a long-term viewpoint, these markets are not altogether desirable; China the largest, is governed by political rather than economic considerations, whereas the other importers of Italian N-fertilizers are actively engaged in setting up and expanding their own industries.

The new plant developments in Sicily, however, promise to improve Italy's competitive ability, especially in respect of complex fertilizers. The availability of cheap sources of hydrogen in oil and gas, cheap energy, sulphur in terms of ore, a new promising source of potash and the proximity of North African phosphates, notably those of Tunisia, offer advantages which few centres of fertilizer manufacture anywhere in the world can rival. Sicily's favourable situation along the shipping lanes to the Middle and Far East and to Africa further improve Italy's prospects, not only to maintain but to expand further her position amongst the major fertilizer suppliers of the world.

# RW-300 Digital Computor at Monsanto's Luling Ammonia Plant

## Has increased efficiency and product yield

Computor control room at Monsanto's ammonia plant

ONE of the world's largest synthetic ammonia plants, Monsanto Chemical's Barton Plant at Luling near New Orleans, U.S.A., is now computer-controlled. Opened by Lion Oil Company in 1954 with a nominal capacity of 300 tons per day, the plant was taken over by Monsanto in 1955 on the merger of the companies and production was increased to about 450 tons per day. Installation of a seventh compressor raised production to about 525 tons per day; an eighth compressor is now being installed.

Production figures for the computer-controlled system have not been given but it can be estimated that to give a reasonable return on the investment would require an increase of $3\frac{1}{2}$ to 5% on the 525 tons per day production peak.

### The Process

The Barton Plant, built by Chemical Construction Company, is a typical ammonia plant and consists of the following process units: primary reformer, secondary reformer, synthesis reactor. A block diagram of a typical plant is shown (Fig. 1) giving approximate pressures, temperatures and analyses of the flow streams involved.

### Why An Ammonia Plant Was Chosen

It may be asked why, of the many large plants run by Monsanto, the ammonia plant was chosen. There are three main reasons:—

1. It was necessary to choose a process where a reasonable improvement would have a chance of justifying the expense of the computer installation. This put a certain minimum on the value of production per unit time which could be considered.
2. It was necessary to make a complete disclosure of all plant process and operating data to the computer manufacturers, Thompson-Ramo-Wooldridge Computers Company. Regardless of the integrity of the outsiders, some processes could not be made available for this type of scrutiny. The ammonia process, however, is well known and the plant design is freely available.
3. It was necessary to have a modern, well instrumented plant, so that the computer installation could be judged on its own merits and not be obscured by improvements resulting from chemical engineering changes or additional control installation. The Barton plant met this requirement.

### The Problem

The synthesis unit should be operated at its design pressure and fed the correct proportion of $H_2$ and $N_2$. The simple synthesis reaction indicates a $H_2 : N_2$ ratio of three to one. In practice it is found that pressure and

equilibrium considerations alter this ratio somewhat and maximum conversion is attained with a slightly different ratio.

The exact value of this ratio varies from plant to plant and must be determined experimentally.

The correct ratio is maintained by regulating the ratio of $H_2 : N_2$ at the exit of the shift converter. This ratio is also one which varies from plant to plant and is not exactly the 3 : 1 value predicted by the reaction formula because of the different solubility of these gases in the product ammonia.

The chief variables which control the primary reformer are:—

1. Reformer temperature.
2. Total natural gas feed.
3. Total steam feed as a ratio of natural gas feed.

Reformer temperature is maintained by a separate furnace combustion control.

The secondary reformer has two main variables which are important for its control:—

(a) Ration of air flow to process gas flow from the primary reformer.

(b) Ratio of flue gas to process gas.

The addition of flue gas allows independent regulations of the $H_2 : N_2$ ratio and of the reformer temperature. It thus permits methane content in the output to be maintained at a sufficiently low value to give efficient operation.

In the CO converter, the proper amount of steam must be added to convert the CO to $CO_2$, shifting the $H_2 : N_2$ ratio from about 2.7 : 1 at the exit of the secondary reformers to about 3.1 : 1 at the exit of the converter.

The primary reformer feed gas is preheated by heat exchangers. A five-stage compressor is used to achieve the 5,000 p.s.i. pressure used for the synthesis unit.

The important plant control variables which must be used by the computer for its task and which must be investigated in the computer control study are outlined in Table I and Fig. 2.

## The Plant Study

In November 1957 Monsanto and TRW signed a contract for a joint study of the Barton ammonia process. With the plant description and control requirement statement in Table I and Fig. 2 they proceeded to develop a mathematical model by which a computer might control the process and by which the economic return from computer control could be determined.

The mathematical models consisted of a series of arithmetical and algebraic statements

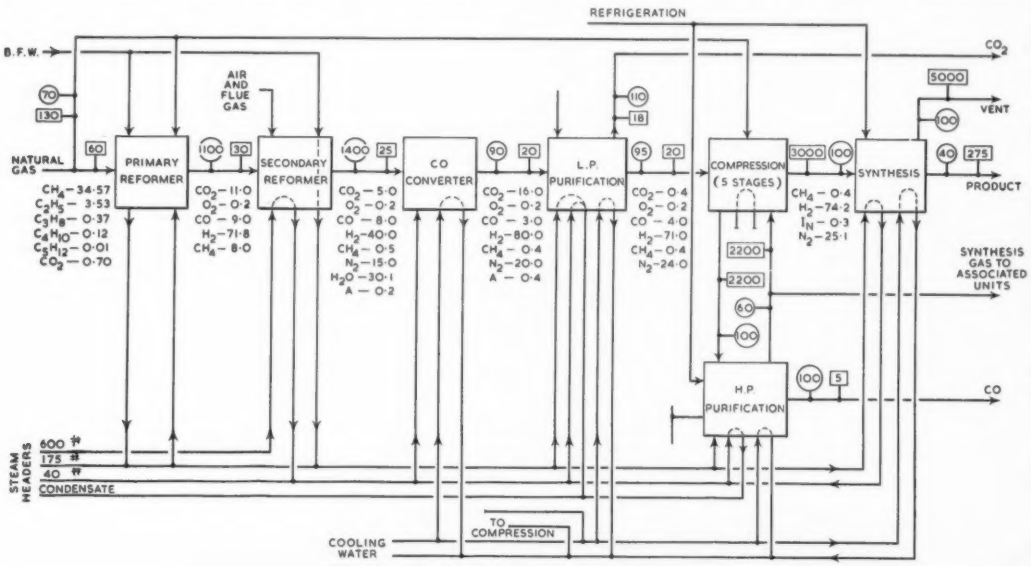
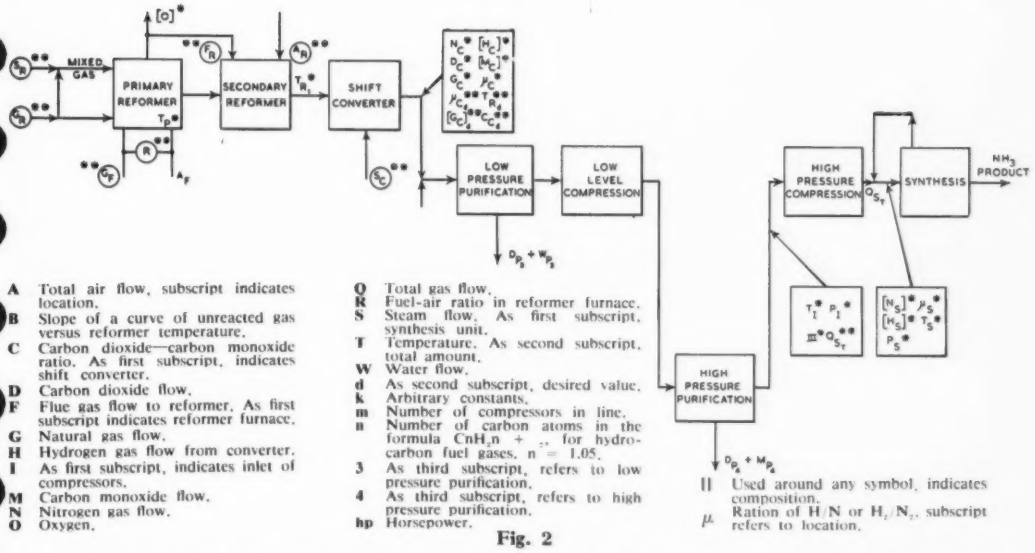



**Fig. I. Block diagram of a typical plant**




**A** Total air flow, subscript indicates location.
**B** Slope of a curve of unreacted gas versus reformer temperature.
**C** Carbon dioxide—carbon monoxide ratio. As first subscript, indicates shift converter.
**D** Carbon dioxide flow.
**F** Flue gas flow to reformer. As first subscript indicates reformer furnace.
**G** Natural gas flow.
**H** Hydrogen gas flow from converter.
**I** As first subscript, indicates inlet of compressors.
**M** Carbon monoxide flow.
**N** Nitrogen gas flow.
**O** Oxygen.
**Q** Total gas flow.
**R** Fuel-air ratio in reformer furnace.
**S** Steam flow. As first subscript, synthesis unit.
**T** Temperature. As second subscript, total amount.
**W** Water flow.
**d** As second subscript, desired value.
**k** Arbitrary constants.
**m** Number of compressors in line.
**n** Number of carbon atoms in the formula $C_nH_{2n+2}$, for hydrocarbon fuel gases, n = 1.05.
**3** As third subscript, refers to low pressure purification.
**4** As third subscript, refers to high pressure purification.
**hp** Horsepower.
**||** Used around any symbol, indicates composition.
**μ** Ration of $H_2/N_2$, subscript refers to location.

**Fig. 2**

of the relationships of the dependent variables of the process to the level of the various independent variables and of the important process parameters.

The team found that theoretical expressions covering the required relationships did not exist and could not readily be developed. Instead it was necessary to make statistical studies of available plant data to determine empirical relationships between the variables and parameters. Regular plant log sheets were used wherever possible and in other cases special plant runs were made to obtain sufficient data for a particular correlation.

An early decision was that the computer should operate "on-line," i.e., that it would not require an operator to translate its findings into plant process changes. However, its control would be "supervisory" rather than "dynamic" since it would make its corrections by altering the set points of the regular plant instruments instead of changing valve settings directly. The model would therefore provide for computation of the "desired values" of several process parameters which would then be used as the basis for calculation of the set points of the plant flow quantities. Equations would also be included for a slow modification of the model for computing some of the process parameters should the original model not exactly follow the physical system. Thus the principle of "adaptive control" was applied here.

Many of the controller constants could be determined by trail and error adjustment after the computer had been installed. Actual forms

**Table I**

**I. Primary Control Variables of an Ammonium Plant**
1. Reaction gas flow to the primary reformer, $G_R$.
2. Air flow to secondary reformer, $A_R$.
3. Flue gas flow to secondary air blower, $F_R$.
4. High pressure steam to primary reformer, $S_R$.
5. Low pressure steam to CO converter, $S_C$.
6. Fuel gas flow to the primary refromer furnace, $G_F$.
7. Fuel air ratio, primary refromer furnace, R.

**II. Basic Measurements and Calculated Factors in Ammonia Plant Control**
1. Desired synthesis gas feed rate, $Q_R$.
2. $H_2 : N_2$ ratio at the synthesis reactors, $U_R$.
3. $H_2 : N_2$ ratio at the CO converters, $U_C$.
4. Fuel gas content at the CO converters, $G_C$.
5. Secondary reformer temperature, $T_R$.

**III. The Objectives to be attained**
1. Maintain the maximum gas flow in spite of changing weather and process conditions.
2. Maintain an optimum hydrogen to nitrogen ratio.
3. Maintain an optimum methane concentration at the exit of the shift converter unless in conflict with 1 or 2 above.
4. Maintain maximum shift efficiency if not in conflict with objectives 1 through 3 above.
5. Under reduced flow conditions (storage tanks, fuel, etc.) maintain objectives 2-4.
6. Immediately and safely reduce raw materials flows to compensate for any loss of compression.
7. Provide a log of important process variables.
8. Provide the operator with messages in case of abnormal process or instrument conditions.
9. Provide safety features such that instrument or computer malfunctions are detected, alarmed, and prevented from affecting process.
10. Control the fuel and air to the reform furnace.
11. Maintain a specified steam to dry gas ratio at the exit of the secondary reformer and at the exit of the CO converter.

of the control equations themselves could also be altered under operating conditions as plant results showed the desirability or necessity of such action.

In consequence the actual computer model would be one which was handfitted to the Barton plant ammonia unit and would be uniquely capable of controlling that plant.

### Control Relationships

The engine-compressor system represents a major part of the capital cost of an ammonia plant and consequently is most likely to cause bottlenecks. The highest possible production rate and therefore the maximum economic return is obtained by operating the compressor system at capacity. Ambient conditions, especially temperature, have a definite influence on the compressor efficiency. Allowable compressor horse power falls as the temperature rises.

When the calculated flow rate differs from the operating rate the computer moves to bring the plant into line. When it does this it has to take into account the inertia of the plant. In addition the computer automatically takes into account compressor failure or the availability of additional compressor capacity.

Relationships were also developed for the control of reformer temperature against unreacted feed gas content, and for the control of secondary converter temperature, desired carbon dioxide : total carbon ratio, computation of overall flow rates to the process, and a furnace temperature control programme.

### Installation

The mathematical study was completed in the late spring of 1958 and the final report of the study team along with a proposal from TRW for a computer control system was presented to Monsanto in July 1958.

Rather than install a new electronic system of instrumentation it was decided to apply the computer to the existing pneumatic instruments.

**View of Monsanto's ammonia plant from reformers shows CO converters (foreground), then cooling scrubbers, control room, MEA units, and synthesis converters**

Since the information required by the computer was in pneumatic form it was necessary to convert it by means of transducers. Conversely, the outputs from the computer had to be converted by transducers from electric to pneumatic signals.

Each instrument which is set by the computer is provided with a selector switch which allows the operator to choose the mode of control, computer or local. Certain portions of the control calculations will not take place if the particular variables are not on computer control. The operator works at a desk which incorporates a visual display of the control system. The status of the output system is indicated by a bank of lights. From the desk he can effect immediate transfer to and from computer control. Safety devices are built into the system to protect against power and instrument failure.

**Economics of the Project**

Having decided that the computer control system was possible, Monsanto had to decide whether it was economically jusifiable. The cost estimation for instrumentation, submitted by TRW, was less than half the figure estimated by Monsanto's engineers. And the final figure was slightly above even Monsanto's original figures.

Estimating the profit return from this type of installation is described by Monsanto as being largely a matter of engineering evaluation since no previous experience with a progress computer was available. The return can be subdivided under four headings:—

1. More product for sale
2. Reduced cost of production
3. Increased efficiency of raw material use
4. Improved quality of product

The effect of uncontrolled variables can be minimised. Atmospheric conditions in particular have a great effect. By optimising plant conditions as these variables change, throughput has been improved.

Even making all possible allowances the computer showed, as a production unit, an adequate return on investment.

In addition to the economic advantages, the computer has a number of technical features which are valuable. It readily makes available information on factors such as mass flow rates which is not otherwise easily obtained. There is no need to wait until the process is in a steady state before adjusting significant variables.

**The Computer**

The Ramo-Wooldridge Corporation, now Thompson-Ramo Wooldridge Computers, had previously developed the RW-30 airborne computer, an all-transistor, light-weight computer for aircraft navigation, automatic piloting and fire control. To expand their business they decided to adapt the RW-30 for process control applications, calling the new model the RW-300.

It was this model which was installed at the Barton plant.

**Cost**

No figures are available from Monsanto as to the cost of the computer installation. However, the basic RW-300, excluding input and output equipment, costs $98,000. A complete system could cost anything from $150,000 to $500,000.

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## Plastic-Coated Fertilizers

APPLICATION of plastic-coated fertilizer has been suggested by Dr. Kirk Lawton of Michigan State University. Coating conventional fertilizers with various plastics slows down the rate at which they release their various constituents to the soil. The coating also prevents plants from feeding more quickly or heavily than they really need to. Use of this new fertilizer material is recommended particularly for agricultural pasture and lawns.

The coatings used were vinyl acetate, paraffin, acrylic resin and polyethylene. Each reduced the rate at which soluble fertilizers dissolved in soils.

A coated fertilizer lost only 8.4% of its potassium while uncoated fertilizer lost 81.3% in the same period of time.

## *Supplies - Prices - Trends*

# Good Prospects for Nitrogen Industry

THE promising start of 1960/61 fertilizer year has been marred by the widespread autumn weather throughout Western Europe. Particularly hard hit were France and the U.K. where severe floods in many parts of the two countries brought autumn farm activities to a virtual standstill. Moreover, it is now feared that the adverse effect on farm incomes generally may result in reduced purchases in the spring, the main fertilizer season, although more optimistic opinions predict that in order to compensate for the winter crop failures and the higher loss of plant nutrients from the soil by leaching, farmers may book their spring demand of fertilizers, in particular, of nitrogen fertilizer. The level of consumption in Western Europe, which in 1959/60 had increased steeply to nearly 3.1 million tonnes of fertilizer nitrogen and in 1960/61 had been expected to rise at least 5% to 3.25 million tonnes N, may now remain static.

In the U.S.A. the autumn fertilizer season, after a slow start, appears to have fully claimed producers' resources and supplies are currently reported to be tight.

### Variations in Export Markets

Principal export markets—in Asia, the Near East and South America—show wide variations. Exports by Japan to her traditional customers in the Far East which receive the bulk of deliveries during the second half of the calendar year are reported to be satisfactory. In India and Pakistan the level of consumption of nitrogenous fertilizers is increasing and for the time being the increased needs are met by imports. China, the world's largest export market for fertilizer nitrogen, suffered both severe drought and floods which are reported to have caused widespread harvest losses. This is believed to account for her failure to make the customary substantial fertilizer purchases in Western Europe during the early autumn. In many of the small export markets in Africa and South America, results to date are inconclusive but it appears that the strong position established over the past two years by West German nitrogen fertilizer exporters in several countries has not been maintained.

The general level of world prices of nitrogenous fertilizers has not been affected by the disappointing season. There is traditionally a build-up of fertilizer stocks at this time of year at producers' works and in the distribution pipeline. Lower domestic sales have, without doubt, upset the schedules of several major producers, who in the early autumn had seen their order books full and a fairly tight supply position developing especially between November and February, and there have been reports of a number of distress sales in export markets, below the level $29 per tonne f.o.b. in bulk for ammonium sulphate or corresponding prices for bagged material and other forms of fertilizer nitrogen. These have not, however, influenced the overall picture to any significant extent and it would seem that several producers' confidence, which had earlier been shaken, was restored when China came on the market in the latter half of December. The quantities purchased, mostly in West Germany, are reported to be relatively small and the full extent of Chinese purchases remains a critical factor. If they failed to reach 280,000 tonnes N in this fertilizer year it would have a very severe impact on the West European balance of supplies. In this eventuality the major producers' endeavours to maintain stable prices may not prevail under the pressure of available supplies.

### By-product Ammonium Sulphate

The overall trend of production is rising and any substantial accumulation of stocks could introduce a lasting weakness into markets. A factor which is increasingly affecting market sentiment is the prospect of mounting supplies of by-product ammonium sulphate

in caprolactam manufacture*. As yet virtually confined to the U.S.A., Netherlands and Germany, mounting supplies will originate from 1962 onwards in all major nitrogen producing countries.

Despite this temporarily unsettled outlook sight must not be lost on the one hand of the present high absolute level of world nitrogen demand both in agriculture and in industry of over 12 million tonnes N—an increase of 40% in five years—and in the longer term of the vast pent-up demand in both underdeveloped and more advanced countries which, in response to national and international efforts to raise living standards, is turning into actual requirements. In this light the prospects of the world's major nitrogen industries—which at the same time are rationalising operations by improved techniques, use of cheap raw materials sources and greater integration with petrochemicals—are favourable.

## SUPPLY

### United States

Contrary to earlier years' trends anhydrous ammonia output in September receded 4.4% to 363,601 short tons. Production of various nitrogenous fertilizers, nitric acid and industrial nitrogen, however, rose seasonally.

| | September 1960 | August 1960 | 1959/60 Average |
|---|---|---|---|
| | '000 short tons | | |
| Ammonium nitrate (100% $NH_4NO_3$) ... ... | 259.3 | 236.5 | 248.8 |
| Ammonium sulphate | | | |
| Synthetic ... ... | 71.0 | 63.9 | 83.9 |
| By-product ... ... | 40.4 | 44.2 | 47.5 |
| Nitric acid (100% $HNO_3$) | 281.0 | 255.0 | 267.5 |
| Nitrogen solutions (100%) | 53.8 | 50.7 | 71.4 |

Preliminary reports for the closing months of the year indicate strong domestic demand which absorbed the seasonally rising production. Anhydrous ammonia production in 1960 is expected to have reached 5.2 million short tons. The slight improvement in the steel rate is reflected by greater output of by-product ammonium sulphate which in October totalled 42,576 tons. Stocks of ammonium sulphate—synthetic and by-product—which at the end of October totalled about 240,000 short tons, are reported to have declined significantly to meet consumers' needs.

* NITROGEN 8, P.34.

As the result of adequate domestic outlets the availability of nitrogenous fertilizers for exports was restricted at the close of the year. Deferment of awards under ICA fertilizer programmes is expected to impose heavy demands on nitrogen fertilizer producers in the U.S.A. in the coming months when contracts are expected to be placed.

### Central and South America

The buoyant fertilizer nitrogen demand, which in 1960/61 is expected to boost imports to 285,000 tonnes N, is also reflected by the great number of new projects in many countries. Prominent in a number of projects is the Chemical and Industrial/Girdler Group which through its participation in the International Development and Investment Co. (IDI) is shortly expected to place orders with its associates Phoenix-Rheinruhr A.G. of Dusseldorf for the supply of equipment for the major nitrogen fertilizer plant at Cartagena, Columbia.†

### Pakistan

To augment domestic nitrogen fertilizer supplies the Government plans to instal near Sukkur on the River Indus an ammonium sulphate plant with an annual capacity of 52,500 tonnes N. At present modest quantities of ammonium sulphate originate from the Daud Khel ammonium sulphate plant where start-up difficulties have delayed the rated output of 50,000 tonnes-a-year product being achieved. Pakistan's two other projects—the urea/ammonium sulphate plant under construction by the Japan Plant Association at Fenchuganj, East Pakistan, and the urea/ammonium sulphate/ammonium nitrate plant at Multan—both to be based on natural gas and expected to supply 150,000 tonnes N annually towards the country's fertilizer needs, are due to be completed in 1963. In the meantime the level of consumption is rising moderately and imports in the current year are expected to total some 100,000 tonnes nitrogenous fertilizers, mostly ammonium sulphate and urea.

### Iran

The 30,000 tonnes N ammonium nitrate plant at Shiraz, which is to be based on natural gas and a Fauser-Montecatini ammonia plant,

† NITROGEN 8, P.48.

is nearing completion by Constructors John Brown Limited of London. Natural gas supplies are now available following the completion of the 140-mile long 10-inch diameter gas pipeline from Gach Saran which will supply the new plant and meet domestic and industrial fuel needs in Shiraz. The line has been tested and a gas treatment plant at the Shiraz terminal is under construction.

**United Kingdom**

Final results for the fertilizer year 1959/60 show that total deliveries to domestic consumers totalled 421,200 tonnes N, an increase of 21.9% compared with the preceding year. Of this total ammonium sulphate, of which about 80% is incorporated in compound fertilizers, accounted for 202,300 tons N and other nitrogenous fertilizers 218,900 tons N, the latter representing an increase of 70,000 tons N—approximately 50%—over the preceding year.

Ammonium nitrate, originating from the new Stanford-le-Hope plant of Fisons Limited and increased output by Imperial Chemical Industries Limited, and complex fertilizers—domestic and imported—accounted for the bulk of these increased supplies.

Fisons Fertilizers Limited is now engaged in the construction of a new granulating plant at its Cliff Quay, Ipswich, Works. This plant and ancillary alterations to storage will cost approximately £600,000 and will come into operation in mid-1962. When completed, it will replace the older of the two existing granulating plants, which has been working since 1937 and which will be dismantled. The new plant together with its associated storage and bagging arrangements will incorporate the very latest techniques, and is being designed and engineered direct by Fisons Fertilizers Limited. Like all Fisons Fertilizers granulating plants, it will have facilities for the incorporation of ammonium nitrate in its product. A £1.25 million expansion programme by Scottish Agricultural Industries Limited includes at Sandilands Works, Aberdeen, conversion from production of compound fertilizers based upon superphosphate to the production of ammonium phosphate and the more concentrated compounds which can be made from it. Production capacity at the new plant will be over 100,000 tons a year.

Industrial nitrogen demand—estimated at 130,000 tons N in 1959/60—is mounting, although severe competition is foreseen in export markets for many of the products which are prompting the greater requirements. Mr. A. F. C. Speyer, Commercial Director of I.C.I. General Chemicals Division, recently referred to this in connection with the activities of the company's Cassel Works whose established business in cyanides and newer products is meeting severe competition in the Common Market. To retain its position in the export field Cassel Works, according to Mr. Speyer, would have " to maintain efficiency and keep down the cost of manufacture." Three-quarters of Cassel Works cyanide output is exported and in fact represents one-quarter of all the exports of the General Chemicals Division. I.C.I. has been unable to satisfy all demands for cyanide, and while holding a dominant share of world trade in this compound, now has " vigorous and youthful competitors who manufacture it by more modern processes. These competitors are springing up in Canada, Italy and Japan." The Cassel Works will, according to Mr. Speyer, have to find ways of making cyanide more cheaply in order to compete with these new processes.

**Western Europe**

Among the small number of West European countries who are actively engaged in expanding nitrogen capacity, France is prominent. The country's leading producer, Office National Industriel de l'Azote, in the early autumn raised installed capacity at the Toulouse plant to 540 tonnes a day ammonia. Pierrefitte, Societé Génerale d'Engrais et des Produit Chimiques, has completed work on the expansion of its ammonia plant to a daily capacity of 240 tonnes. Ammonium sulphate is to be produced at coke-oven plants at the Homecourt works of the French state company Union Siderurgique Lorraine (Sidelor) and at the Carling coking plant of Houillères du Bassin de Lorraine. Koppers France S.A. will supply the necessary plant.

Norway's largest nitrogen producer, Norsk Hydro, plans to expand the annual capacity of its urea plant at the Glomfjord works from 70,000 tonnes to 100,000 tonnes. Still awaiting

a final decision is the scheme to build an ammonium sulphate plant at Mo-i-Rana in Northern Norway; Fangel and Company of Oslo is believed to have a major interest. It is expected that this decision will not be long delayed since the Norwegian Government has announced that it intends to erect a coking plant for Spitzbergen coal beside the Mo-i-Rana nationalised iron works; the coke-oven gases from the plant would serve as feed for an ammonia plant. The sulphuric acid requirements of the ammonium sulphate unit would be met by a pyrites-based plant.

Rising industrial nitrogen demand in Sweden has led to the decision by A. B. Svenska Salpeterverken of Köping to instal additional nitric acid capacity at a cost of SKr. 4 million. The extension is to be completed in 1962.

In Holland the Dutch State Mines, the country's leading nitrogen producer, announced the start of production of a lime ammonium nitrate product containing 23% N. This is in line with trends already evident in France and Belgium. The fertilizer is to be marketed domestically.

The recent wave of strikes in Belgium is seriously affecting the nitrogen industry and this year's production is likely to fall well below the 1959/60 total of 330,000 tonnes N.

## EXPORT PRICES

### Ammonium Sulphate

Despite isolated instances of small parcels of ammonium sulphate and lime ammonium nitrate being sold at distress prices in recent months, the general export price level in Western Europe remains in the range of $29-$34 per tonne f.o.b. ammonium sulphate in bulk. Recent sales to Pakistan by Austrian and Belgian suppliers are reported to have been concluded at $40.60 and $42.60 per tonne in bags, c. and f. Karachi. While well within the above price bracket, these sales compare unfavourably with the prices paid by India in September when West European and Japanese tenders were accepted at £13 18s. per tonne in 100kg. jute bags f.o.b. (equivalent $38.90).

### Ammonium Nitrate

Current quotations for ammonium nitrate (34% N) range from $58-$63 per tonne f.o.b. Lime ammonium nitrate (20.5% N) remains slightly below the price level of ammonium sulphate in the range of $26-$34 per tonne in bulk f.o.b.

### Urea

Export demand for urea to the Middle and Far East has remained strong without, however, resulting in a significant change in its price level. West European supplies quote upwards from $79 per tonne f.o.b. and Japanese material is quoted at $86-$90 per tonne f.o.b.

## DOMESTIC PRICES

### United States

During 1960 the cost of fertilizers to farmers rose, according to the U.S. Department of Agriculture, by 1%. Further increases are expected in 1961 but this is likely to be offset by cost reductions of other items in farmers' expenditure. Farm incomes are expected to rise in the first half-year; but fall in the second half. Among the early decisions of the new administration the review of export costs of agricultural products is expected.

| | |
|---|---|
| Ammonium nitrate | $67 per short ton f.o.b. plant in bags |
| Ammonium sulphate | |
| (coke oven) | $32 per short ton bulk f.o.b. plant |
| (synthetic) | $35 per short ton bulk f.o.b. plant |
| Urea (45% N) (fertilizer grade) | $100 delivered |
| Calcium ammonium nitrate (20.5% N) | $48 f.o.b. cars at port |
| Calcium cyanamide | $57 per short ton f.o.b. works in bags |
| Nitrogen solutions (40.8% N) (100%) | $126 per short ton tank card f.o.b. plant |
| Anhydrous ammonia | |
| (fertilizer grade) | $29 per 2,000lb. tanks |
| (refrigeration grade) | $94.50 per 2,000lb. tanks ex works |

Prices of anhydrous ammonia in the East, Mid-West and North Central states remained at $92. In California the price situation remains uncertain; most producers, however, continued selling at the lower price level which on 1 January 1961 was raised $3 to $75 per short ton *ex* works. The posted price for nitrogen solutions increased $6 to $132 on 1 January 1961.

Among 78 important products on which the U.S. is offering tariff cuts in return for concessions on U.S. products at the 1961 Geneva meeting of the General Agreement on Tariffs and Trade (GATT) is ammonium phosphate. On the other hand potassium nitrate is among a list of 200 items published by the U.S. Government in addition to an original list of products, for which import duty reductions may be arranged within the framework of the GATT agreement.

**UNITED KINGDOM** — **Comparative London Prices (per ton)**

| Product | A year ago £ s. d. | Now £ s. d. | Subsidies £ s. d. |
|---|---|---|---|
| Nitrate of soda (16% N) d/d | 24 3 0 | 23 13 0 | 7 4 0 |
| Sulphate of ammonia (21% N) d/d | 20 14 6 | 20 9 6 | 9 9 0 |
| Nitrochalk (15.5% N) d/d | 18 10 0 | 18 5 5 | 6 19 6 |
| Nitrochalk (21% N) d/d | 24 0 0 | 23 11 6 | 9 9 0 |
| Nitroshell (23% N) d/d | 26 5 0 | 25 16 6 | 10 7 0 |
| Muriate of potash (60% $K_2O$) ex-store | 20 1 0 | 20 1 0 | None |
| Superphosphate, powdered (18% $P_2O_5$) d/d | 14 8 6 | 13 15 0 | 6 9 0 |
| Basic slag (15% $P_2O_5$) d/d | 7 10 0 | 7 10 0 | 3 2 9 |
| Bone meal (3.7% N x 20.5% $P_2O_5$) ex-store | 29 10 0 | 26 12 6 | None |
| Hoof and horn meal (13% N) ex-store | 48 15 0 | 49 0 0 | None |

**WEST GERMANY** — **West German Prices (per tonne N)**

| Product | January 1961 | February/June 1961 |
|---|---|---|
| Ammonium sulphate nitrate (26% N) | DM 1,130 | DM 1,150 |
| Ammonium sulphate (21% N) | DM 1,120 | DM 1,140 |
| Calcium ammonium nitrate (20.5% N) | DM 1,150 | DM 1,175 |
| Urea (46% N) | DM 1,070 | DM 1,090 |
| Calcium nitrate (15.5% N) | DM 1,310 | DM 1,330 |

**FRANCE** — **French Prices (New Francs per 100 kg. in 20 tonne lots)**

| | January 1961 | | February/May 1961 | |
|---|---|---|---|---|
| | without taxes | with taxes | without taxes | with taxes |
| Ammonium Sulphate | | | | |
| 20% N | 24.10 | 26.78 | 24.70 | 27.44 |
| 20.60% N | 24.81 | 27.57 | 25.41 | 28.23 |
| 21% N | 25.28 | 28.09 | 25.88 | 28.76 |
| Urea (prills) | | | | |
| 45% | 52.65 | 58.50 | 53.92 | 59.91 |
| 46% | 53.82 | 59.80 | 55.12 | 61.24 |
| Nitrate of ammonia (ammonitrate) | | | | |
| 20.50% | 23.36 | 25.96 | 23.92 | 26.58 |
| 27.50% | 30.03 | 33.37 | 30.75 | 34.17 |
| 33.50% | 34.54 | 38.38 | 35.38 | 39.31 |
| 34% | 35.06 | 38.96 | 35.96 | 39.90 |
| 34.50% | 35.57 | 39.52 | 36.44 | 40.49 |
| Calcium nitrate | | | | |
| 15% | 22.46 | 24.96 | 23.11 | 25.68 |
| 15.50% | 23.21 | 25.79 | 23.88 | 26.53 |
| Calcium magnesium nitrate | 21.25 | 23.61 | 21.86 | 24.29 |
| Ammonium nitrate (nitrated ammonium) | | | | |
| 33.50% | 33.54 | 37.27 | 34.35 | 38.17 |
| 34.50% | 34.54 | 38.38 | 35.38 | 39.31 |
| 34.90% | 34.94 | 38.82 | 35.79 | 39.77 |
| Sodium nitrate | | | | |
| 16.00% | 27.26 | 30.29 | 27.76 | 30.84* |
| | | | 28.12 | 31.24† |

* February † March-May

**BELGIUM** — **Belgian Prices**

| | Ammonium Nitrate | Ammonium Sulphate | | Perlamide | Cyanamide | |
|---|---|---|---|---|---|---|
| | 22.5% N | 20.5% N | 20% N | 18% N | 18% N | 22% N |
| January | 248 | 229 | 221 | 347 | 326 | 379 |
| February | 248 | 229 | 221 | 347 | 326 | 379 |
| March | 225 | 236 | 228 | 347 | 326 | 379 |
| April | 255 | 236 | 228 | 347 | 326 | 379 |

# FREIGHTS

In recent weeks reported charterings for nitrogenous fertilizers have been almost exclusively in respect of shipments by Italian producers, mainly for Asian destinations. Heavy bookings for sulphate of ammonia from Venice/Ravenna/Ancona to South China pushed the going rate of freight up to 61s. 0d. a ton on f.i.o. terms, with a further 2s. 0d. for Northern Chinese ports. A fixture for the same area from Savona was made at 3s. 6d. a ton less. Priolo, which has come into the limelight during the past half-year with the commissioning of new works, chartered two 9,500 tonners to Korea, paying $8.50 for Pusan discharging and $8.30 for Mokpo. East German shippers were represented by the payment of 50s. 0d. a ton, also for ammonium sulphate, from Rostock to one port West Coast India.

## Soviet Bookings

Minor traffic of interest concerns bookings of Soviet produced ammonium nitrate at 26s. 0d. a ton f.i.o. for a 1,600 tonner Odessa to Thessaloniki and a parcel of 700 tons from Riga to Konakri at 44s. 0d. Chilean nitrate shippers covered a cargo for the U.S. Atlantic by taking up a Liberty-type vessel on the Brazilian coast at $800 a day, necessitating a voyage through the Panama Canal at the charterers' expense en route to her loading port. Such operations are frequently resorted to in this trade because there is virtually no outward cargo for tramp shipping to the West Coast of South America. In this connection a recent quotation from London shipbrokers is most interesting and unusual. It calls for an 11,000 tonner to load a full cargo of unspecified fertilizers from one or two ports in Germany to three ports in Chile.

## French Shipments

Little has been heard of the big movements of calcium ammonium nitrate from France to Egypt, save for a few fixtures from Dunkirk to Alexandria at 37s. 6d. a ton less 3s. 0d. for cost of discharging. It seems probable that most of this traffic is covered on the Paris market, largely by French ships. Northwest Europe too has been silent of late, although not necessarily because no business has been done. On rising markets there is a tendency on the part of some charterers to withhold information about freights paid. There is, however, a big unfilled call for sulphate carriers to South Korea from Antwerp/Hamburg and from Vancouver, both sources quoting the identical rate of $8.50 a ton f.i.o. Further tonnage is sought for ammonium sulphate to South Spain from Hopewell, Va., but, on to-day's firm market, the quotation of $5.25 appears to be optimistic. One sector where freights do not rise is outwards from Europe to the U.S.A., tonnage still being obtainable at about $3.25 from Rotterdam to South Atlantic and Gulf ports. But such figures are only acceptable to the limited number of very "tender" ships which are forced to take fertilizer cargoes in the winter months more or

**FERTILIZER FREIGHTS**

| Importing Area | Shipment from | DECEMBER FREIGHTS* 1960 | 1959 | 1958 |
|---|---|---|---|---|
| South China | N.W. Europe | 65s. 0d. | 60s. 0d. | 57s. 6d. |
| ,, | Adriatic | 61s. 0d. | 54s. 6d. | 52s. 6d. |
| India/Pakistan | Adriatic | 46s. 0d. | 47s. 6d. | 45s. 0d. |
| ,, | N.W. Europe | 48s. 0d. | 53s. 0d. | 46s. 0d. |
| ,, | U.S. Gulf | $10.75 | $9.00 | $8.50 |
| ,, | British Columbia | $9.00 | $8.85 | $10.00 |
| India | Chile | 100s. 0d. | 90s. 0d. | 100s. 0d. |
| Taiwan | U.S. Gulf | $10.00 | $9.50 | $9.50 |
| ,, | N. Pacific | $8.25 | $7.25 | $8.65 |
| Philippines | N. Atlantic | $10.20 | $9.75 | $9.35 |
| ,, | N.W. Europe | $8.60 | $8.05 | $7.70 |
| Greece | N.W. Europe | 35s. 0d. | 33s. 0d. | 35s. 0d. |
| ,, | U.S. Gulf | $7.50 | $7.40 | $7.75 |
| Egypt | N.W. Europe | 34s. 0d. | 33s. 0d. | 29s. 0d. |
| ,, | Adriatic | 20s. 0d. | 23s. 9d. | 19s. 0d. |
| Brazil | U.S. Gulf | $5.75 | $5.50 | $6.75 |
| South Africa | N.W. Europe | 40s. 0d. | 36s. 0d. | 38s. 3d. |

* Per long ton net, exclusive of loading and discharging costs.

less as "paying ballast" as it would be dangerous to send them across unladen.

The general outlook for all freights this winter is strongly in favour of shipowners. In the longer trades such as India and South America to Europe current freights are 30% to 40% above this summer's levels. Moreover demand for shipping is widening and cross-voyages like U.S. Atlantic to Japan and the Indian Ocean trades are having to pay well to attract ships. If a heavy winter demand for grain carriers occurred in the "key" North Atlantic to U.K./Continent trade, further increases are likely in the longer trades. Unless, however, homeward freights rise to such levels that shipowners will readily travel out in ballast, this upward trend in freights should not seriously affect fertilizer shippers as with coal almost dead and the motor car traffic in decline, fertilizers remain one of the few forms of employment still available to work tonnage out to the high-freight distant markets.

The statistics given on Page 21 of fertilizer freights are based mainly on known charterings, but when no recent information is obtainable "notional" rates are presented, based on bookings for other commodities on similar routes.

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### Ammonium Polysulphate at Pilot-plant stage

FERTILIZER containing more plant nutrient than any other at present manufactured may become available if ammonium polysulphate goes into commercial production. Following the successful conclusion of laboratory studies Tennessee Valley Authority, Wilson Dam, Alabama, are starting pilot plant trials.

Primarily, ammonium polyphosphate is a mixture of ammonium orthophosphate and ammonium pyrophosphate, containing about 77% plant food—16% nitrogen and 61% $P_2O_5$—this compares with diammonium phosphate which contains about 74% plant food. Plant food content apart ammonium polyphosphate has another important advantage in that it is less costly to handle, ship and store than any other fertilizer material.

As a fertilizer, this new high analysis material can be expected to have a variety of applications. It can be used as a conventional fertilizer. It can also be used by liquid fertilizer producers to make highly concentrated solutions. Dissolved in water, ammonium polyphosphate gives a liquid fertilizer containing as much as 44% plant food—about 10% nitrogen and 34% $P_2O_5$—or about the same concentration as that made directly from superphosphoric acid and ammonia (conventional furnace acid used to make liquid fertilizer gives a material with about 32% plant food).

Another important property claimed for ammonium polyphosphate is its use in liquid fertilizer. Like superphosphoric acid the new material prevents impurities from precipitating, obviating the need to use wet process acid instead of the more expensive furnace acid.

To make ammonium polyphosphate, T.V.A. charges ammonia and superphosphoric acid to a reactor. Reaction conditions vary. Typical ranges for grades such as 15 - 61 - 0 to 17 - 60 - 0 are 10 to 300 p.s.i. at 340°-400°F with retention time in the reactor at 20-50 minutes.

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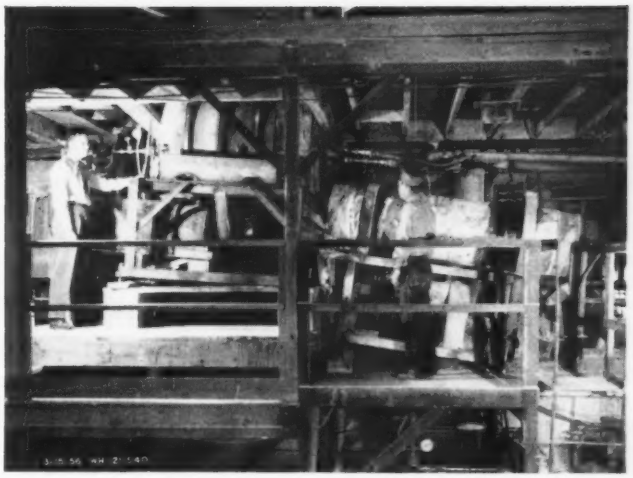
## Containers for Ammonium Sulphide

DURING a recent chemical experiment a 40 to 50% aqueous solution of ammonium sulphide ( $(NH_4)_2S$) was poured into a 10-litre zinc container which was then closed with a screw-on cap. A short time afterwards, the bottom of the container which was soldered, suddenly burst. The cause of the unexpected formation of pressure was sought and it was found that gases were formed by contact of the ammonium sulphide with the zinc container. It is believed that zinc ammonium sulphide was produced and also hydrogen from the hydrogen sulphide also formed : $\longrightarrow (NH_3)_xS(?) + H_2S + H_2$. It is therefore advisable to ensure that ammonium sulphide does not come in contact with zinc and that only pure iron containers should be used for collecting ammonium sulphide.

# T.V.A.'s New Process for Producing Diammonium Phosphate



T.V.A. pilot-plant for diammonium phosphate

ONE of the prominent features of the recent major fertilizer plant projects in the U.S.A. has been the emphasis on diammonium phosphate units based on wet phosphoric acid.

Increased use of high-analysis fertilizer by U.S. farmers, and producers' efforts to reduce transport costs by including as high a proportion of plant nutrient into a ton of fertilizer, are the main factors behind the expansion in the wet-process phosphoric acid, superphosphates and diammonium phosphate plants and expansions planned or under construction in the United States. Much of the new construction, which amounts to a capital outlay of £30-£40 million, will be completed this year or early next year, and is situated in Florida and the far West. Thus, Virginia-Carolina Chemical are setting up a diammonium phosphate unit. Recently California-Spray Chemical brought into operation their large fertilizer complex at Kennewick (*Nitrogen 7*, P. 29). Rated capacity is 200 tons per day of mono- and diammonium phosphates.

## Advance in Ammonium Phosphates

Ammonium phosphates—mono-and diammonium phosphates particularly—show a 53% advance in their first half-year statistics. Output in the first half of 1960 rose to 133,000 tons ($P_2O_5$ basis) compared to only 87,000 tons in 1959. Expected year-end total is 230,000 tons.

Outstanding advances in the economic use of phosphoric acid in the manufacture of complex fertilizers are attributable to Tennessee Valley Authority. Their latest contribution in this field is a new process, just being developed, for producing granular diammonium phosphate fertilizer. This has the advantage over previously developed crystallizer methods in that it can use low-cost, wet-process phosphoric acid without a purification step.

By taking advantage of chemical heat in the reaction of phosphoric acid and ammonia, recycle rates and drying requirements are reduced below those of some competing processes. The grade of product depends on the purity of the phosphoric acid available, ranging up to 21-53-0 when electric-furnace acid is used. The process is being adapted to the production of various grades, some containing potash. Key equipment in the process is the ammoniator. Acid is partially neutralised in a tank followed by completion of the ammoniation to diammonium phosphate in the ammoniator-granulator drum.

Excess ammonia must be fed to the drum to produce diammonium phosphate; therefore, a scrubber is required to recover $NH_3$ from the exhaust gases. The phosphoric acid is fed to the scrubber to absorb the ammonia, and the solution is fed to the preneutralizer. A recycle ratio of about 3 to 1 is required for control of granulation. Physical properties of the closely

sized granular product are excellent, it is stated.

### Pilot-Plant Operations

Tests were made by T.V.A. with electric-furnace phosphoric acid containing 78 to 82% phosphoric acid or with commercial wet-process phosphoric acid containing 54% $P_2O_5$. Additional water was required in the process which was equivalent to using acid of considerably lower concentration. Anhydrous ammonia was fed as a liquid.

Analysis of the wet process acid used was:

| $P_2O_5$ | $Al_2O_3$ | $Fe_2O_3$ | $SO_3$ | Cat | acid value as $H_3PO_4$ |
|---|---|---|---|---|---|
| 54.7 | 1.2 | 1.3 | 2.7 | 0.07 | 71.3 |

The continuous ammoniator-granulation pilot plant was used at a production rate of 0.5 tons an hour. In the tests anhydrous ammonia and wet-process phosphoric acid containing 54% $P_2O_5$ were used. All the acid was fed to the scrubber to simplify fluid flow and to give minimum loss of ammonia. Water had to be added at some point to prevent excessive thickening of the slurry in the preneutralizer tank. Also, unless water was fed with the liquid ammonia in the preneutralizer, freezing of the slurry occurred in the vicinity of the ammonia spanger because of the cooling effect of the vapourizing ammonia. When no water was added to the 54% $P_2O_5$ acid fed to the scrubber, loss of ammonia was 2.2% of the total ammonia fed in the process. When the acid was diluted to 50% $P_2O_5$ in the scrubber the loss of ammonia was only 0.1%.

Liquor was withdrawn continuously from the scrubber to maintain a nearly constant level and was fed to the preneutralizer tank. Anhydrous liquid ammonia and water were fed through the same distributor to the preneutralizer. It was found that an $NH_3 : H_3PO_4$ mole ratio of 1.3 could be used in the preneutralizer without excessive loss of ammonia. Loss of ammonia in tests ranged from 1.6 to 3.3%.

Good granulation was obtained in one test at a recycle ratio of 2.7 with a dried product containing 0.6% moisture at a temperature of 142°F. When the product was cooled without drying the recycle was at 82°F and contained 1.3% moisture. Good granulation was obtained but a higher recycle ratio was required (3.0 vs 2.7) than when using dried recycle product. Temperature in the ammoniator-granulator decreased from 191°F when hot recycle was fed to 178°F when cool recycle was fed. Ammonia evolved from the granulator drum to be recovered in the scrubber was 7% and 2.1% in these two tests respectively. In other tests ammonia recovered ranged up to 12% to the total feed to the process.

### Screened Product

When drying was employed, the screened product contained 19.9% N, 50.4% $P_2O_5$ and 0.9% water. When no drying was used, the product was of somewhat lower grade because of the higher moisture content and contained 19.7% N, 49.6% $P_2O_5$ and 2.0% water. The granules were well rounded and strong.

### Scrubber

The scrubber consisted of a 2ft. by 10ft. cylindrical tower containing 8ft. of wood grid-type packing. Scrubbing liquor was dispersed over the packing by a double cone distributor. The usual recirculation rate was 10 gallons a minute. Gas from the ammoniator-granulator entered the tower at a temperature of about 120°F and at a rate of about 350 cu. ft. a minute. In some tests, the proportion of acid fed to the scrubber was controlled to maintain an $NH_3 : H_3PO_4$ mole ratio of about 1.0 in order to reduce corrosion of the mild steel; the remainder of the acid was fed to the preneutralizer tank. In all other tests, all the acid was fed to the scrubber. Best ammonia recovery occurred when all the acid was fed to the scrubber and control of the operation was also simplified. Loss of ammonia in the scrubber off-gas was found to increase with increase in pH and temperature of the scrubbing liquor. Fluidity of the liquor was probably a factor in ammonia absorption and T.V.A. suggest that the water content necessary to give a scrubber effluent that could be handled readily varied widely with the pH or $NH_3 : H_3PO_4$ mole ratio; at a pH of less than 1 about 20 to 25% water was needed while at a pH of 3 to 4 about 70 to 80% water was required. Corrosion of the mild steel of the scrubber was severe with hot liquor (120° to 150°F) at a pH as high as 3 to 4. Stainless steel is therefore recommended for construction of the scrubbing system.

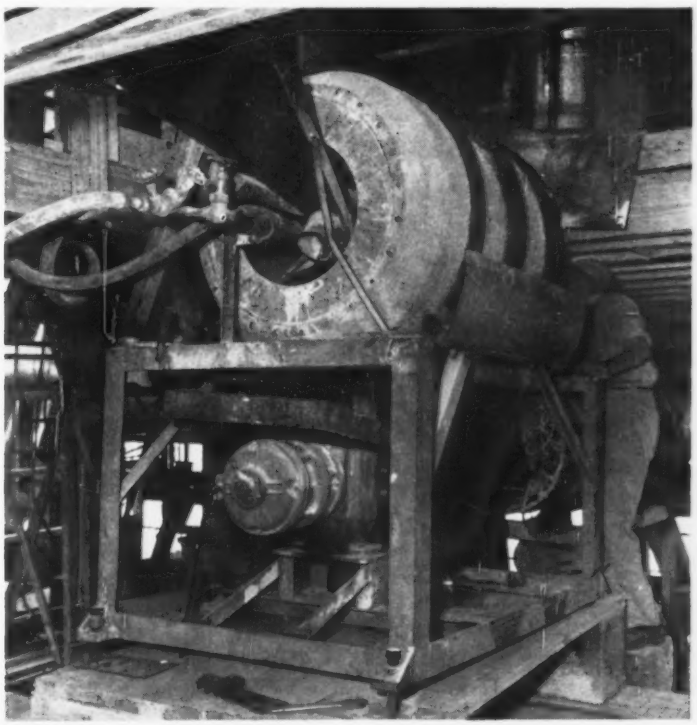
### Preneutralizer Tank

Effluent from the scrubber was fed to the preneutralizer which consisted of a 14in. diameter open tank 3½ft. high equipped with an agitator. Ammonia and acid effluent were fed through separate ¼in. standard pipe size circular spangers with perforations directed toward the centre of the tank. The ammonia spanger was positioned below the acid spanger. Stainless steel was used throughout for construction of the preneutralizer system. The slurry produced in the preneutralizer was discharged through a side overflow-pipe of 2ft. level. The tank was equipped with a hood and air ejector system for exhausting the moisture-laden exhaust gases.

It was found that an $NH_3 : H_3PO_4$ mole ratio of about 1 : 3 could be obtained in the preneutralizer tank without excessive loss of ammonia. To keep the slurry sufficiently fluid to permit distribution in the ammoniator-granulator drum, the acids containing 54% $P_2O_5$ were diluted so that the slurry leaving the preneutralizer contained 15 to 24% water. The amount of water added was equivalent to the use of acid containing 37 to 43% $P_2O_5$. About 300lb. of water per ton of product were evaporated. Evaporation of water controlled the temperature in the preneutralizer in the range of 235° to 250°F. The pH of the solution varied from 5.0 to 5.5 with an $NH_3 : H_3PO_4$ mole ratio of 1.3 to 1.35.

### Ammoniator-Granulator Drum

The pilot-plant ammoniator-granulator drum was 3ft. by 3ft. and contained 9in. retaining rings on each end. It was operated at 20 r.p.m. The slurry from the preneutralizer flowed by gravity through a saw-toothed distributor, located above the rolling bed of solids in the drum. About 225lb. of anhydrous liquid ammonia per ton of product were added beneath the bed in the drum through a 30in. six-slot type distributor normally used for feeding ammonia or ammoniating solution in production of conventional mixed fertilizer. Granulation was controlled primarily by rate of recycle feed which ranged from 2.7 to 3.5lb. per pound weight of product when using concentrated wet-process acid. A recycle rate of 3.7lb. per pound weight of product was used



**View of feed end of T.V.A.'s continuous ammoniator**

when feeding electric-furnace acid. Other factors affecting granulation were $NH_3 : H_3PO_4$ mole ratio in the drum, evaporation rate in the drum, particle size and moisture content of recycle and slurry composition. Less agglomeration and more evaporation occurred when the $NH_3 : H_3PO_4$ mole ratio was 2.00 than when it was 1.90. Best results were obtained when granulation was controlled so that less than 10% of the granulator product was plus six mesh in size and more than 50% was minus 10 mesh. Control of granulation to give this size resulted in greater retention of ammonia in the ammoniator-granulator and more evaporation of water in the drum and the rotary dryer or cooler. Most of the recycle requirements, it was found, could be provided by the minus 10 mesh fines from the screens, and the amount of oversize was small. Ammonia evolved from the drum to be recovered in the scrubber ranged from 2 to 12% of the total fed to the process. Twenty-five to 49% of the total water introduced in the process was removed in the ammoniator-granulator drum.

When cool recycle product was fed, the drum temperature was about 10°F lower (183° as against 193°F) and about 25% less water evaporated in the drum (27% as against 36% of the total water for the process). A somewhat higher recycle ratio for control of granulation is therefore required.

## Acid Concentration

The approximate recycle rates required for various acid concentrations are given below:—

| Acid Concentration % $P_2O_5$ | Recycle Ratio lb./lb. product |
|---|---|
| 43 | 2.7 |
| 39 | 3.0 |
| 37 | 3.5 |
| 34 | 5.0 |
| 32 | 8.5 |

If drying was not used, the recycle rate would be slightly higher at the higher acid concentrations and much higher at the lower concentration. In practice feed acid could be a blend of filter acid (32% $P_2O_5$) and concentrated acid (54% $P_2O_5$). The additional impurities in the 32% acid would be expected to affect the operating characteristics. The higher proportion of solids in the weak acid might pose problems due to settling out and would affect the consistency of the slurry in the pre-neutralizer.

## Dryer or Cooler

For drying or cooling, a conventional rotary dryer was used, 3ft. in diameter by 24ft. long, and containing eight 8in. radial flights extending almost the full length of the dryer. A countercurrent flow of air was used for drying and for cooling the product. When the product was dried, 1,800 cu. ft. per minute of air entered at 240° to 270°F and left at 180° to 210°F. Product temperature reached 180° to 210°F. Ammonia loss in the dryer varied from 2 to 4% of the total and increased with loss of ammonia. Other factors that increased the loss of ammonia were increases of $NH_3 : H_3PO_4$ mole ratios and increases in the moisture contents of the products.

When the product was cooled to 80° to 85°F without drying, 500 cu. ft. per minute of air entered at 85°F and was exhausted at 135° to 140°F. Loss of ammonia in cooling was about 1.5%.

The product was sized on double-deck screens having 6- and 10-mesh openings. The oversize material was pulverized in a chain mill and rescreened.

## Storage

Unconditioned products dried to 0.6 to 1% moisture after 30 days' storage had no bag set or only a light set and contained no lumps after a short drop. Material cooled without prior drying, contained 2% moisture and after 30 days the unconditioned product had a medium bag set and contained 15 to 20% ½in. lumps, which broke up to 1% lumps after four drops.

## Advantages

Desirable features of T.V.A.'s process include the following:—

- Either electric furnace or wet process phosphoric acid can be used and the process is adaptable to acids in concentrations as low as 32 to 34% $P_2O_5$.
- Recycle rates required are lower than in many other granulation processes.
- The heat of chemical reaction is utilized in the evaporation of water to the extent that drying may not be required.
- The product granules have good physical properties.
- Equipment required is of conventional type.

# Japan's Plans for Urea Plants

## Calcium cyanamide production cuts announced

LESS calcium cyanamide for fertilizer use is being produced in Japan following the recent decision by a number of Japanese carbide manufacturers to reduce substantially or to relinquish sales of the fertilizer-grade product. In 1958-59, calcium cyanamide production was 89,000 tonnes N and represented 8.2% of Japan's total N production of 989,000 tonnes N, and 9% of the total fertilizer N production. A year ago, Showa Denko K.K. closed down their plant at Kase, and this was followed by a similar action by Tokai Electrode Manufacturing Ltd. (Tokai Denkyotu Seizo K.K.). This spring Tekkosha Company and Ibigawa Electric Industry Company Limited (Ibigawa Denki Kogya K.K.) announced that after 1962 they did not propose selling calcium cyanamide fertilizer.

### Plants Shut Down

In the 1956-57 fertilizer year, production of calcium cyanamide was 463,000 tonnes but in 1958-59 dropped to 390,000 tonnes of which Ibigawa produced 16,653 tonnes, Tokai 5,356 tonnes, Tekkosha 6,936 tonnes and Showa Denko at Kase 33,845 tonnes. Thus the plants now shut down, or scheduled to be closed, produced 61,790 tonnes or 15.8% of total calcium cyanamide production.

Reasons advanced for the closure are that calcium cyanamide can no longer compete with other nitrogen fertilizers and the price relationship has continued to worsen. While other nitrogen fertilizers become cheaper, no further price reductions can be made for calcium cyanamide.

Although calcium cyanamide for fertilizer application has become less attractive, the product continues to be required by the plastics industry for melamine production. It is therefore likely that output of calcium cyanamide for this application will increase.

### Urea Production

In the urea field production capacity in 1959 was 260,000 tonnes N. Manufacturers' recent long-term estimates up to August 1962-July 1963 indicated that a further increase in capacity is now necessary and they are therefore planning new plants or expansion of existing ones to meet the 1962-63 requirements.

It is estimated that new facilities and expansions will raise urea capacity in Japan by 298,300 tonnes.

Companies that have decided to enlarge or construct new urea plants up to the present time are given in the table below. Besides these companies Kyowa Gas Chemical Company are investigating the construction of a urea plant of 50,000 tonnes capacity a year which will utilize the waste gas derived from acetylene gas production from natural gas. Toyo Gas Chemical Company are to double their ammonia plant at the Niigate site, and the increased ammonia production will be used entirely for production of urea, so raising this company's capacity by 50,000 tonnes.

**Japan's Construction Plans for Urea**

| Company | Present Production | Additional Production Capacity | Construction Period |
|---|---|---|---|
| | tonnes | tonnes | |
| Toyo Koatsu (Hokkaido) ... ... | 129,000 | 30,000 | January 1961 - September 1962 |
| ,, ,, (Ohmuta) ... ... | 86,000 | 3,600 | October 1960 - September 1961 |
| Nitto Chemical ... ... ... | 32,900 | 3,600 | October 1960 - March 1961 |
| Japan Gas Chemical ... ... ... | 54,700 | 5,300 | October 1960 - March 1961 |
| Showa Denko ... ... ... ... | 80,000 | 50,000 | October 1961 - September 1962 |
| Nissan Chemical ... ... ... | 39,800 | 2,400 | September 1960 - September 1961 |
| Befu Chemical ... ... ... | 35,000 | 5,000 | July 1960 - November 1961 |
| Ube Industries ... ... ... | 48,000 | 10,000 | September 1960 - March 1961 |
| ,, ,, ... ... | Second period | 65,000 | October 1961 - October 1962 |
| Sumitomo Chemical ... ... ... | 66,000 | 34,000 | April 1961 - July 1962 |
| Mitsubishi Chemical ... ... ... | 82,000 | 27,000 | October 1960 - September 1961 |

### More Ammonium Sulphate Plants

While ammonium sulphate production capacity might be considered more than adequate, it is of interest to note that Yawata Chemical Company, a subsidiary of the important ferrous metals producer Yawata Iron and Steel Company, have recently announced that they are negotiating with Dowa Mining Company for the possible future building of an ammonium sulphate plant in Japan, to be based on coke-oven gas and on pyrites-derived sulphuric acid. Negotiations are also reported to be taking place between Yawata Chemical and Shin Nippon Chisso Hiryo, another Japanese nitrogen producer. Yawata are said to be prepared to supply the other company with coking gas, from one of its parent company's ferrous metals combines, for processing into nitrogenous fertilizer at the Shin Nippon Mizumata plant.

Ammonium sulphate production based on coking gas is also being considered by Kawasaki Steel Corporation. This company plans to supply the necessary gas to its subsidiary, Kawasaki Industries Company, for processing into fertilizer.

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## Comprehensive Method for Determining Nitrogen in Fertilizers

Two methods have been in use for determining nitrogen in fertilizers: The classical Kjeldahl method for fertilizers containing organic nitrogens and a reduced-iron method for fertilizers containing high chloride-nitrate ratios. Now Dr. Charles W. Gehrke and co-workers of the University of Missouri report a comprehensive method for the determination of nitrogen in fertilizers.

Discussing the procedure before the Association of Official Agricultural Chemists (A.O.A.C.) recently, Dr. Gehrke reported that the new procedure analyzes fertilizers containing either high chloride-nitrate ratios, organic adopted by A.O.A.C. in 1957, but changes have been made that allow the method to be used to analyze samples containing organic nitrogens such as calcium cyanamide, urea or other refractory nitrogen materials.

### The New Method

As in the reduced iron method water and 5 grammes of electrolytically reduced iron powder are added to a fertilizer sample containing less than 0.185 gramme $NO_3^-$. Then 20 ml. of 50% $H_2SO_4$ are added. The iron and sulphuric acid react to release hydrogen which reduces the nitrates to ammonium salts. The iron, Dr. Gehrke reports, is superior to conventional thiosulphate reductants for $NO_3^-$ in the presence of chlorides which allow notable gases, such as nitrosyl chloride, to form during reduction; the new method does not.

### HgO as Catalyst

In two further stages, $K_2SO_4$ is added to raise the boiling point of the solution and HgO to catalyze conversion of organic nitrogen to $NH_3$. First 4 grammes $K_2SO_4$ and then 1.3 grammes HgO are added and the solution is boiled for about 15 minutes. Then 10 grammes of $K_2SO_4$ and 0.7 grammes of HgO are also added and boiling is continued for about 50 minutes. Sequence and amount of $K_2SO_4$ are important, it is reported. With addition of 4 grammes $K_2SO_4$ before initial boil and 10 grammes afterwards a reaction temperature of 360°C can be reached; addition of more than 4 grammes initially causes the mass to solidify. The 2 grammes of catalyst added, i.e., HgO, is about three times the amount used in previous methods.

After reaching 360°C alkalis and sulphide or thiosulphate reagents are added and the mass is distilled conventionally.

With A.O.A.C. approval a collaborative study of the method is being undertaken over the next year as a prelude to possible adoption in the U.S.A.

# New Routes to Urea

## Monsanto uses CO, S and $NH_3$

## Chemico's unique heat conservation method

A NEW ROUTE to urea is reported by Monsanto Chemical's Lion Oil Division. Carbon monoxide, sulphur and ammonia are reacted together to form urea and by-product hydrogen sulphide. The reaction conditions are mild—temperature, for instance, being only 120°C—but Raymond Franz and Fred Applegath of the Monsanto Division have suggested that the economics of sulphur recovery are a big drawback in the present process involving the reaction of hydrogen sulphide with sulphur dioxide. It is believed, however, that since there are several well-tried processes whereby $H_2S$ can be reacted with $SO_2$ the difficulties mentioned are likely to refer to the problem attaching to the extraction of $H_2S$ from the process stream which would entail adsorption by some means, such as by the use of methylamines, Krell process, etc. These sulphur recovery processes could make the new Monsanto process an attractive one.

### Unusual Features

The Monsanto process has been tested in a 2lb.-a-day urea pilot plant and has two unusual features; it utilizes carbon monoxide obtained as by-product from ammonia production and operates at 50-300 p.s.i.a. whereas the present urea processes use carbon dioxide and pressures of 2,500 to 3,000 p.s.i a.

Few details have been released to date about the new process. Ammonia, carbon monoxide and sulphur (dissolved in methanol) are fed continuously to an autoclave running at 210°F and 3,000 p.s.i.a. Urea and $H_2S$ form, and unreacted ammonia and CO are recycled to the autoclave. $H_2S$ is oxidized back to sulphur prior to recycling. The percentage yield of urea is reported to be in the upper 80's.

No plans are in hand for commercializing the process which is covered by U.S. Patent No. 2,857,430. There is a possibility that the process may be used to make various substituted ureas. Lion Oil Division have investigated some related reactions using primary aliphatic and other amines for ammonia.

### Chemico's New Process

Cost-cutting material flow and pressure-zone innovations that promise a reduction in the price of urea by about $5 per ton are envisaged using a new process developed by Chemical Construction Corporation, New York, and now in operation at Co-operative Farm Chemicals Association's plant at Lawrence, Kansas. The process is reported to be free of problems often associated with urea manufacture such as corrosion, maintenance of product quality and solidification; it is also stated to employ a unique method of conserving the heat that results from this operation, and to require significantly less steam than is the case with other methods.

The new process saves on electric power and cooling water, and provides longer "on stream" time allowing the plant to run without shutdown for maintenance and adjustments.

### General Flow Scheme

Ammonia and carbon dioxide are fed to a reactor or autoclave, in which pressure is 2,800-3,000 p.s.i. and temperature 345°F. The ammonium carbonate formed breaks down to urea and water. Since the carbamate on one hand and the urea and water on the other are in equilibrium if temperature, pressure or rate of flow are disorganized, the reaction shifts and solidification and shutdown occur.

Decomposition and absorption occur in two stages, the double-stage operations result from the need for careful separation of the reactor effluent components: ammonia, carbon dioxide, urea and carbamate. In most autoclaves conversion into urea in one pass is only about 50%. It is at this stage that Chemico has introduced a change: most of the recycled $NH_3$

is taken directly from the top of the first absorption stage, instead of through an intermediary step, as in other urea processes such as those of Allied Chemical, Du Pont, Inventa, Montecatini and Pechiney-Grace. Thus carbamate solution is mixed with a gaseous stream. Heat released at the mixing stage forces the urea-carbamate reaction to the ammonia side in the final decomposition stage. Steam is thereby saved and the urea yield may be increased. A special pressure zone causes ammonia to be condensed with normal cooling water. Water for a carrying medium is not required and more urea is obtained. The aqueous urea solution leaving the process is 76% urea as against about 70% in other processes. Evaporation is required to obtain the final product.

## Russian Fertilizer Exports in 1959

THROUGHOUT the Communist countries there is a pronounced shortage of fertilizers. To assist in relieving this shortage the Soviet Union exports small quantities of fertilizers but compared with Russian exports of fertilizer raw materials these are negligible.

In 1959 the U.S.S.R. exported 150,600 tonnes of nitrogen fertilizers and of this total 81,300 tonnes was ammonium nitrate. Destinations to which this fertilizer was sent were as follows:—

| | | | | | |
|---|---|---|---|---|---|
| Albania | ... 5,700 | Greece | ... | 22,100 |
| Bulgaria | ... 25,900 | Rumania | ... | 17,700 |
| China | ... 6,100 | Others | ... | 2,100 |
| Finland | ... 1,700 | | | |

There is no evidence that the U.S.S.R. is exporting ammonia.

The nitrogen industry in the U.S.S.R. is comparatively modern. Russian ammonium nitrate (reported at 35% N) is the main nitrogen fertilizer produced, but in the future it is expected that larger quantities of urea, liquid fertilizers and complex fertilizers will be produced. Natural gas, coke-oven gas and natural and refinery gases are the raw materials being employed. Considerable research has been carried out in the Soviet Union on the use of liquid ammonia as fertilizer and the principal fertilizers used in the U.S.S.R. to-day are liquid ammonia and Ammiakat A, a compound of ammonium nitrate (64-67%), ammonia (14-17%) and water (16-22%), giving a nitrogen content of 34-37%.

It will be recalled that Societe Belge de l'Azote du Marly, Belgium, has granted licences to the U.S.S.R. for construction of two ammonia plants and Werkspoor N.V. of Holland has a contract for the erection of three urea plants somewhere in the U.S.S.R.

The only other fertilizer exported in significant quantities are superphosphates. In 1959 the U.S.S.R. shipped to Bulgaria 47% of the total exports of this fertilizer, while Asia received 21% and the remainder was shipped to Albania. Total superphosphate exports in 1959 amounted to 119,100 tonnes.

The U.S.S.R.'s main fertilizer raw material export is apatite concentrates, which in 1959 showed a 10% increase over 1958 exports. In the Eastern Bloc there was an increase of 44.5%. In the same period the Western market for apatite has shown only a 21% increase. Output of apatite concentrates, the main deposits of which are located at Koh, in North-West Russia, amounted to 1,660,700 tonnes.

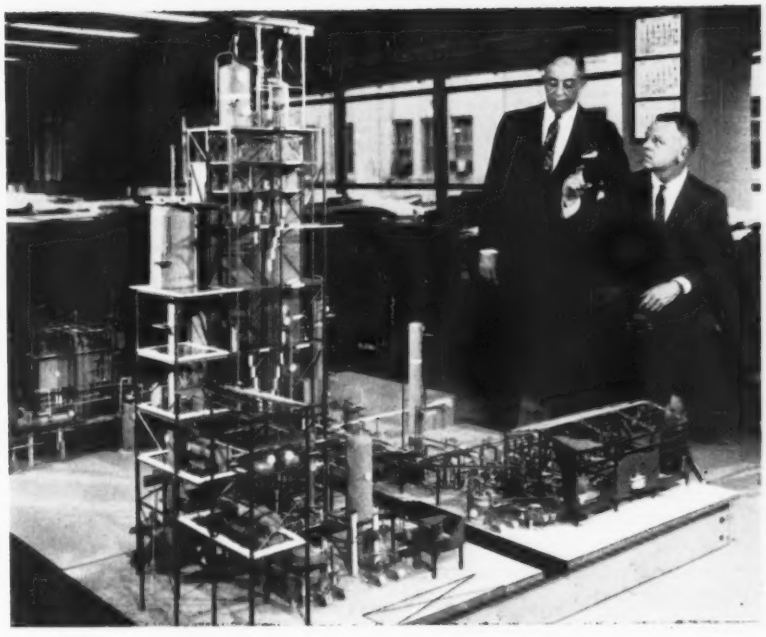
Under the new Seven-Year Plan the U.S.S.R. expects to triple output of apatite. Early in 1959 the U.S.S.R. Ministry of Geology announced the discovery of reserves comprising over 1,600 million tons of apatite.

Potassium salts are also exported in large tonnages by the U.S.S.R. which claims to have the largest reserves of these salts in the world —stated to be 6,500 million tonnes.

The new town of Soligorsh in White Russia will be the centre of the potassium salt industry and is expected to produce many millions of tonnes of potassium fertilizers. In 1959 the Eastern Bloc countries imported 8.2% of potassium fertilizers from the U.S.S.R. while Western countries, including Yugoslavia, imported 41%. Japan imported 38.4% and Canada took 1.8%. The total exports of potassium salts for 1959 from the U.S.S.R. amounted to 438,700 tonnes.

# *First Major Urea Plant on U.S. East Coast*

## SunOlin Plant Now on Stream



**Mr. J. I. Harper, SunOlin's president (seated), and Mr. S. S. Johnson, vice-president, examine the model of the urea plant developed by M. W. Kellogg Co.**

Two years after their formation as a joint company of Sun Oil Company and Olin Mathieson Chemical Corporation, Sun-Olin Chemical Company are operating a 73,000 tons a year (200 tons/day) urea plant.

The $8 million plant built by M. W. Kellogg Company is sited at North Claymont, Delaware, adjacent to Sun Oil Company's Marcus Hook (Pa.) refinery, and employs the Fauser-Montecatini urea recycle process. Besides producing urea, the plant also produces approximately 10 million cubic feet of hydrogen, which Sun Oil uses for ammonia production and for other refining processes.

The SunOlin venture was a natural one when considered in the light of Sun Oil's excess ammonia capacity at Marcus Hook, and Olin Mathieson's efficient sales organisation in plant foods. The latter required urea to complete its line of fertilizer products.

Daily raw materials requirements include 120 tons of ammonia from Sun Oil's refinery, 150 tons of carbon dioxide produced by Sun-Olin's steam methane reformer and 9 million cubic feet of natural gas from Sun Oil's gas fields in south-west Texas. The gas is delivered by pipelines of Transcontinental Gas Pipeline Corporation.

Five grades of urea are produced. Prilled urea is sold for fertilizer and industrial uses, and a special cattle-feed grade is made, in addition to a high purity crystalline urea for leaf spray and industrial uses.

The plant is ideally situated to supply agricultural, dairy, beef-raising areas and industrial urea users of the U.S. Eastern Seaboard.

Employing the Fauser - Montecatini process, in which liquid ammonia and carbon dioxide gas are reacted at 2,800 p.s.i.g. at 870°F to form ammonium carbamate which then decomposes to urea and water, the Sun Olin plant is the only one of its size and type and one of the few in the U.S. which completely converts ammonia and carbon dioxide to urea. It is also one of the few plants in the U.S. equipped to make both prilled and crystalline urea.

### Steam Methane Reformer

Carbon dioxide, used as one of the raw materials in urea manufacture, is provided by a steam methane reformer. Steam and natural gas are heated to about 1,500°F in a furnace in the presence of a nickel catalyst. Most of the methane and other natural gas hydrocarbons are reformed into hydrogen,

carbon monoxide and carbon dioxide. These gases leave the furnace and are reduced to 700°F and passed over an iron oxide and chrome catalyst which converts most of the carbon monoxide to carbon dioxide. The gas, essentially carbon dioxide and hydrogen, is charged to an absorber where the carbon dioxide is absorbed in a solution of mono-ethylamine (MEA). The carbon dioxide is released from the MEA solution by heating and passes to the urea synthesis section. Hydrogen and final traces of carbon oxides pass to a methanator where in the presence of a nickel oxide catalyst the carbon oxides are converted to methane. The hydrogen goes to Sun Oil's refinery for manufacture of ammonia and other uses.

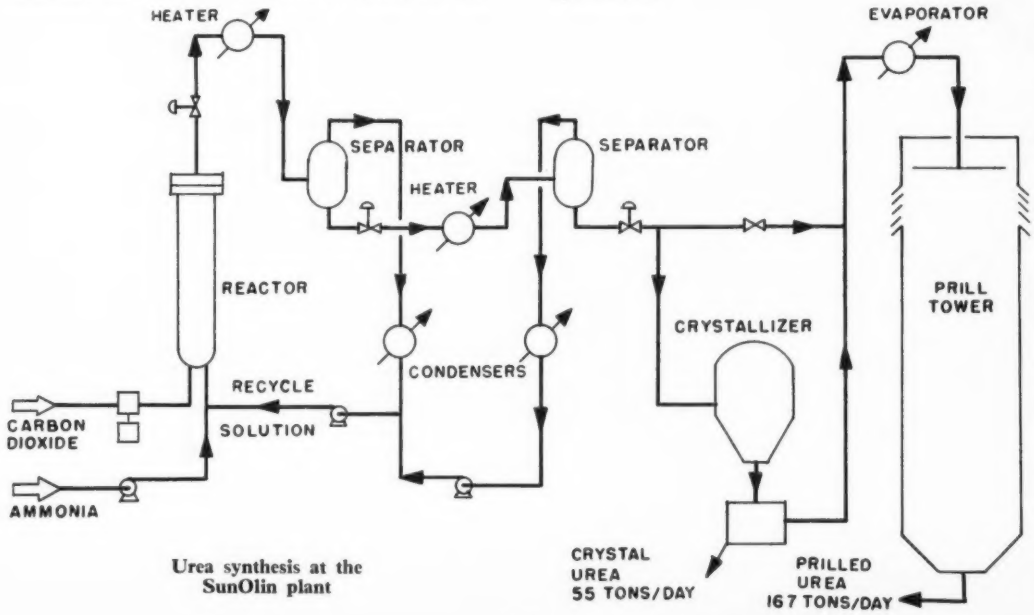
**Urea Synthesis**

Production of 200 tons a day of urea is accomplished by converting 120 tons of liquid ammonia from Sun Oil's refinery and 150 tons of gaseous carbon dioxide from SunOlin's steam methane reformer. These raw materials are compressed to 2,800 p.s.i. and with recycled ammonia and carbon dioxide solution are fed to a reactor where about half of the feed is converted to urea and water. The balance of the stream from the reactor is the unstable ammonium carbamate. Some of the water and ammonium carbamate, which decomposes to ammonia and carbon dioxide, are condensed and returned to the reactor. By recycling ammonia and carbon dioxide, the overall conversion to urea is over 95%.

Urea is recovered from the stream coming from the reactor by reducing the pressure and applying heat. Any water remaining is evaporated under vacuum and the resultant molten urea is "prilled." In addition to making prills, some of the urea solution is sent to a crystallizer where water is evaporated, causing the urea to form crystals, which are centrifuged dried and bagged.

**Use of Plant Model**

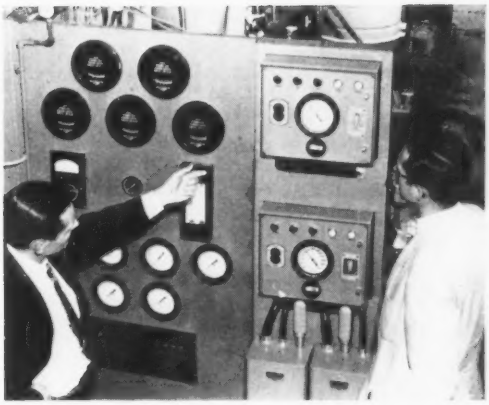
Just under a year from the start of construction, the Sun Olin plant was completed. This rapid progress has been due in no small measure to the use by M. W. Kellogg of a model of the plant created in $\frac{1}{8}$in. to 1ft. scale or 1/33 actual size, using a special technique developed by the constructors to assemble the components. With the plant completed, the model still has its uses. It is used to orient and train plant operators and will add greatly to the ease with which maintenance, repairs and changes can be effected during plant operations.




**Urea synthesis at the SunOlin plant**

# Hydrogen from Ammonia using the Norelco Cryogenerator

## Low cost for small volume user



Control panel of the Cryogenerator

HYDROGEN of 99.9% purity can now be produced in works on demand at a competitive price. This is of particular importance to the small user who has hitherto depended on outside sources of supply of hydrogen produced electrolytically. Manufacture of hydrogen based on dissociation of ammonia is now possible with the introduction of a small unit, the Norelco Cryogenerator, developed by Cryogenerators Inc., a subsidiary of North American Philips Company. The first unit is in operation at Commercial Steel Treat Company at their Detroit plant and will supply 4 million s.c.f. a year, previously obtained from cylinders at a cost of $10/M s.c.f. This company expects to make high purity hydrogen for about $3/M s.c.f., plus amortization. The capital cost of the plant is $85,000-$95,000 which can produce up to 10 M/s.c.f. a year. Other units designed by Cryogenerators Inc. are capable of producing up to 60 M.s.c.f. a year.

### Purity and Cost Advantages

For metal-treatment, hydrogen produced by the Cryogenerator unit has an inherent advantage over the electrolytic product, in that its main impurity is nitrogen — less than 50 p.p.m. — which has little, if any, effect on the treatment process. Commercially produced hydrogen, even in cylinders, contains traces of oxygen or hydrocarbons, which unless held to a minimum can affect metal treatment.

The method of manufacturing hydrogen from ammonia is economic. The ammonia is separated into its components — nitrogen and hydrogen — by heating it in the presence of ferric oxide catalyst. Once the gases are obtained, the mixture is cooled until liquid nitrogen forms, then the phases are separated to obtain pure hydrogen. Key to the process is cooling with the Norelco Cryogenerator or recondenser.

### Separation by Refrigeration

Norelco Cryogenerators operate on a closed-system gas refrigeration cycle. The cylinder houses a compression and a displacer piston — both coupled to a single two-throw crankshaft by separate connecting rods. The crankshaft produces sinusoidal - phased harmonic motions of the two pistons which alternately compress, transfer and expand the working fluid within the cylinder.

The displacer piston divides the space above the compression piston into two sections: the space just beneath the displacer piston is used for compression while the space above the displacer piston is used for expanding and cooling the working fluid. These sections are connected by a channel containing three heat exchangers — water cooler, regenerator and condenser. The working medium — helium in this case — within the cylinder is transferred from the compression space to the expansion chamber and back again by the motion of the displacer.

The process of compression and expansion during one revolution of the crankshaft may be described by the following four phases.

*Phase 1.* The working medium is contained mainly in the compression space where it is compressed by the main piston to maximum pressure.

*Phase 2.* The displacer moves the compressed gas from the compression space to the expansion chamber, the gas flowing through the cooler, the regenerator and to the condenser head. The heat compression is carried off by the water when the gas passes through the cooler. The gas is further cooled in its passage through the regenerator.

*Phase 3.* In this phase the temperature of the gas contained in the expansion space is reduced by the expansion effected by the simultaneous downward movement of the piston and the displacer. The low temperature produced in the condenser head is transferred to the condenser product.

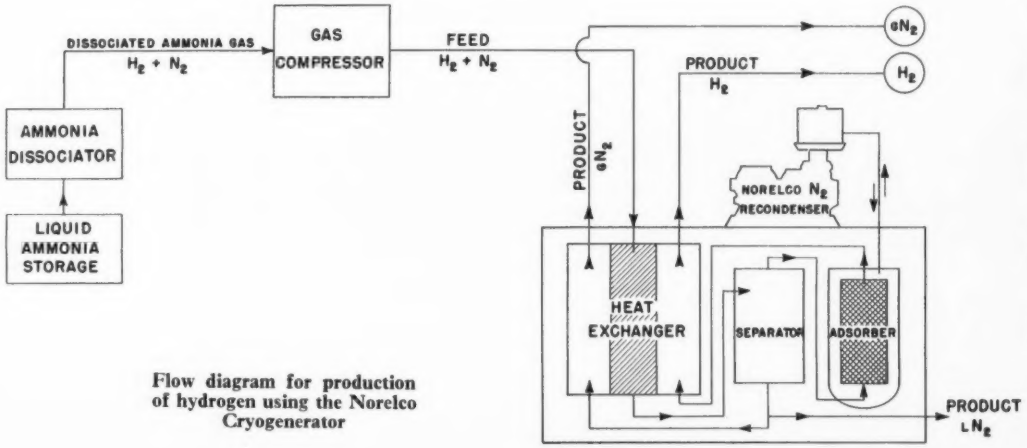
*Phase 4.* The cold gas is driven back to the compression space by the return motion of a displacer. In passing back to the compression space, the working medium absorbs the heat stored in the regenerator during the second phase.

## Hydrogen Production

Dissociated gas mixture of hydrogen and nitrogen and ammonia after compression to 600 p.s.i. passes through an absorber which removes any undissociated product i.e., ammonia, and thence to the low-temperature equipment unit where it is cooled to −275°F by the cold product streams. In the next section a series of three heat exchangers chill the feed with liquid nitrogen—boiling at −310°F atmospheric pressure, −350°F or 250 mm. Hg. abs. or −345°F (50 mm. Hg. abs), giving separation of nitrogen and hydrogen by progressive liquefaction of nitrogen. The stream of now (mainly) liquid nitrogen and gaseous hydrogen, passes through an entrainment separator and an absorber which remove nitrogen. The cold, purified hydrogen then absorbs heat from the incoming feed stream until it is within 5° of ambient temperature. An analyzer checks the purity of the hydrogen coming from the cold unit and if it is not up to standard the hydrogen is automatically recycled.

## Function of Nitrogen

Nitrogen does the work in this process and the liquid nitrogen draining from the hydrogen-nitrogen separator expands at lower pressure in another separator. Dissolved hydrogen flashes off and is combined with another small hydrogen stream (see below). Low pressure nitrogen vapours from vacuum exchangers are exhausted through a feed heat exchanger, pressured to 5 p.s.i. and divided, one stream serving as a purge on the cold unit to keep out air and moisture and the other returning to the system through the recondenser which converts it back to liquid. Liquid nitrogen is used throughout the low-temperature unit to immerse the separators, absorbers and heat exchangers. A supply is maintained in a large Dewar storage flask to furnish coolant to the system for a rapid start-up. Any excess nitrogen is used for purging or inert atmosphere control.




**Flow diagram for production of hydrogen using the Norelco Cryogenerator**

# current events

## UNITED KINGDOM

### Estimating Soil Nitrogen

A new method of estimating soil nitrogen has been described by A. H. Cornfield *(Nature* 1960, **187,** 260). In a series of 48 tests on widely varying soils the total N content and pH amounts of ammonia released by treatment with sodium hydroxide (NaOH) could be correlated with amounts of nitrogen mineralized if the soils were incubated for three weeks at 28°C.

Correlation of results is stated to be highly significant, but since fairly high individual variations are encountered, only approximate predictions should be made by the method. Nevertheless, the NaOH method, being simple and quick, could be useful for screening soils for N available values, using when deemed necessary the more cumbersome incubation method as well.

## CANADA

### Nitrogen Compounds for Foamed Plastics

Canadian Industries Limited is on the point of starting up a plant for production of nitrogen-type blowing agents to be used in the manufacture of foamed plastics, such as the polyurethanes. The company has acquired the Canadian rights to azodicarbonamide, *Kempore*, from National Polychemicals Inc., U.S.A., and will also manufacture dinitrosopentamethylene tetramine. This nitrogen compound is made by E.I. Du Pont de Nemours and Company under the trade name *Unicel* at its Providence, R.I. plant, and by Imperial Chemical Industries under the name of *Vulcacelx B-40*. The product is 40% active with an inorganic filler and stabilizer and is sold in the U.S.A. at ¢69 per lb. in truck-load lots; 80% material is priced at $1.44 per lb. in truck-load lots.

A recent and interesting development in this field is the production of expanded plastics systems in which a blowing agent serves as both blowing and vulcanizing agent. U.S. Patent 2,873,259 for this process is held by Armstrong Cork Co. and discloses use of a known blowing agent—p.p′-oxy*bis*—(benzene sulphonyl hydrazide) from Naugatuck Chemicals *Celogen*—in the form of a novel cellular composition.

## UNITED STATES

### Phillips' Ammonia Storage and Barge Facilities

Four 15,000-ton-capacity ammonia storage tanks, refrigerated to hold the storage temperature at approximately −30°F at atmospheric pressure are being constructed for Phillips Chemical Company. Two storage tanks will be at the Cactus ammonia plant operated by

**San Jacinto ammonia plant near Houston, Texas, now taken over by Smith-Douglass Company**

Phillips near Etter, Texas, and the other two at the company's East St. Louis, Ill., terminal on the Mississippi river.

These atmospheric pressure storage tanks will provide more economical storage of anhydrous ammonia than conventional pressure tanks. Large quantities of ammonia will thus be stored at key distributing points during the slack fertilizer season and will be available for providing ammonia distributors with an adequate supply during the peak sales seasons. The new storage tanks are expected to be completed in time to fill the new tanks prior to the fertilizer sales seasons next Spring.

Also in hand is the construction of two refrigerated anhydrous ammonia barges for Phillip Petroleum by Avondale Shipyards Inc., New Orleans. They will be the largest tank carriers ever constructed for this type of service. Each will have two tanks 11 by 241 feet and will carry, at atmospheric pressure, 1,700 tons of anhydrous ammonia refrigerated to minus 28°F.

### Nitro-carbonitrate Blasting Agents

New outlet for nitrogen products of Monsanto Chemical Company, St. Louis, Mo., U.S.A., is Chromalloy Corporation, also of St. Louis. Monsanto is to supply the company with ammonium nitrate for use in Chromalloy's new explosives programme. The company foresees an immediate market of 30,000 to 40,000 tons a year for its new nitro-carbon nitrate blasting agent in 1961, or about 10% of the ammonium nitrate explosives market.

## PHILIPPINES

### Fertilizer Production in Philippines

During 1959, production of fertilizers in the Philippines amounted to 36,982 tonnes of ammonium sulphate, 88,927 tonnes of mixed fertilizers and 9,258 tonnes of superphosphates.

One producer, National Power Corporation, accounts for the country's ammonium sulphate production and two for mixed fertilizers and superphosphates. Although total output was 40% higher than in 1958, the industry reportedly is not prospering since fertilizers can be imported by the Government and farmer co-operatives at considerably lower prices than those produced domestically.

Particularly for phosphate fertilizers the price disparity is to some extent attributable to the import tax and the 25% premium on foreign exchange that fertilizer manufacturers must pay on imported raw materials; fertilizers imported by the Government and co-operatives are exempt from such charges. As the co-operatives supply in the main large consumers such as sugar and corn growers, local producers are left only the small farmers, and the limited volume of Government-subsidised fertilizer programmes.

In 1959 fertilizer imports by the Philippines at almost 200,000 tonnes represented more than twice the volume of production. Prinicipal items imported were ammonium sulphate, ammonium phosphates and mixed fertilizers. The U.S., the leading supplier in 1957 and 1958, dropped to third place in 1959, Japan and the Netherlands taking first and second places respectively. The U.S., however, supplied most of the 17,000 tonnes of mixed fertilizers imported in 1959. Philippines fertilizer output is expected to decline in 1960 as producers had considerable stock of carry-over at the beginning of 1960 and prices of imported fertilizers probably will remain below those of the domestic product. Long-term prospects for the fertilizer industry in the Philippines are more favourable and producers are planning expansions and process alterations which are expected to lower production costs.

## MEXICO

### Nitrogen Projects in Mexico

In conjunction with the Ministeries of National Patrimony and of Industry and Commerce, Pemex recently announced full details of the manufacture of primary chemicals from petrochemicals in Mexico which in accordance with the state decree is the exclusive prerogative of the nationalized enterprises. Their manufacture will be chiefly based on the company's four largest refineries at Azcapotzalco (Mexico City), Madero (Tampico), Minatitlan (Vera Cruz) and Salamanca (Guanajuato).

Large facilities for synthesis of ammonia are to be established at Salamanca where plants with capacities of 39,500 tonnes $NH_3$ each will come on stream in May 1961. At one time, too, there was to have been a similar ammonia synthesis plant at Chihuahua in the

north, but this project has been postponed. The plants to be set up will have a combined output potential of 480 tonnes a day, or about 130,000 tonnes N a year, of anhydrous ammonia. Sixty per cent of the total production is intended for agriculture, converted to urea and ammonium nitrate, sulphate or phosphate or for direct application. The remainder will be offered to industry.

This new ammonia capacity is expected to meet Mexico's fast rising needs for nitrogenous fertilizers for at least 10 years. The plants at Salamanca and Minatitlan are due to come on stream by May 1961; the ammonia will be produced by steam-reforming natural gas, supplied to the plants by pipelines from the country's gas fields along the Gulf of Mexico.

## FINLAND

### Typpi Oy to Increase N Capacity

In its investigations of nitrogen supply in Finland, a Governmental Commission has proposed that a new nitrogen works should be built with a capacity of 16,000 to 18,000 tonnes N a year, so that in due course the country should become independent of nitrogen fertilizer imports. In 1958, production at the Government's Typpi Oy, Oulu, plant was 34,649 tonnes and consumption 45,200 tonnes.

Recently the Administration Board of Typpi Oy decided that production capacity at the Oulu plant should be raised in order that production should reach 50,000 tonnes N a year in 1962.

The commission suggested that the new works should be subordinated, not to Typpi Oy but with a view to decentralization, to the Government - owned Neste Oy petroleum refinery at Naantali, South Finland. Another reason suggested is the Government's wish to evaluate refinery gases. The Typpi Oy works was originally based on coal, but the plant has now been largely converted to heavy oils which are equally suitable for the Koppers-Totzek gasification and ammonia plant.

Typpi Oy's present production programme embraces the following products: lime ammonium nitrate, calcium nitrate fertilizer, compound fertilizers of the PEC and Odda-type, ammonia solutions and technical nitrogen products. Production expansion at the Oulu plant during the next two years will not mean any change in the range of nitrogen products now currently produced.

A recent addition to the Oulu works is a plant for production of highly concentrated nitric acid with a daily capacity of 20 tonnes. The plant was supplied by Pintsch-Bamag AG. of Berlin.

### Nitrogen Fertilizer Production

Production of nitrogenous fertilizer by type during 1958 and 1959 was as follows:—

**Finland's Nitrogenous Fertilizer Output 1958-59**

(Tonnes)

| Type | N content % | 1958 | 1959 |
|---|---|---|---|
| Calcium ammonium nitrate (Oulu Saltpetre) | 25.0 | 104,837 | 103,892 |
| Calcium cyanamide ... | 21.0 | 2,069 | 3,107 |
| Liquid nitrogen ... ... | 39.0 | 4,895 | 7,644 |
| Anhydrous ammonia ... | 82.35 | 1,476 | 2,542 |

Imports of nitrogenous fertilizer totalled 78,081 tonnes in 1959, a decrease of 9% compared with 86,198 tonnes in 1958.

## NETHERLANDS

### New Fertilizer Plant for Holland

Under the name of Deltachemie, a new plant for the production of mixed fertilizers has been opened at Vlaardingen, Holland. With an annual capacity of 150,000 tonnes of mixed synthetic fertilizers, the plant uses two distinct production methods—that of direct processing, notably of ammonium phosphates, and that of conventional mixing of various finished fertilizers. The second conventional process is said to have reached a high standard of efficiency by research on the part of Deltachemie's parent companies in the field of steam granulation. The plant will be able to produce over 20 various kinds of fertilizer compounds and complexes. Deltachemie is a joint subsidiary of Eerste Nederlandsche Coöperatieve Kunstmestfabriek of Vlaardingen, having a 50% share, the Centraal Bureau*, of Rotterdam, with a 35% share and the Rotterdam company CIV† having the remaining 15%.

Capital investment for the Deltachemie plant totalled some D.Fl. 18 million (about £1,700,000). Of this total only about D.Fl. 1,500,000 (approximately £140,000) was spent outside Holland, mainly on measuring and drying apparatus. The Vlaardingen plant, which stands on a site of 3.5 hectares, will

* National Co-operative Agricultural Purchasing and Selling Society "Central Bureau."
† Co-operative Central Agricultural Buying and Selling Society.

produce mixed fertilizers which will be sold on the home market under the name of *Delta-korrel-Granumix*. Export sales will be undertaken by Eerste Uederlandsche Coöperatieve Kunstmestfabriek, Windmill Fertilizer Works.

## ALGERIA

### Nitrogen Fertilizer Plant for Oran

Azotal (Societe Algerienne de l'Azote), the company set up in Algeria by principal French nitrogen fertilizer manufacturers and a number of banks and financing establishments, is to construct and put into operation a fertilizer works in the neighbourhood of Arz Department of Oran, Algeria. Ammonia will be produced using natural gas as raw material and will be used for manufacture of nitrogen fertilizers. Initially, the company's capital will be only NFr. 200,000, but this is to be increased as required.

At the present time Azotal are studying plans for the proposed plant installations. The low cost of Sahara natural gas—reported at NFr. 0.015 per cubic metre (approximately U.S. ¢9 per 1,000 cubic feet) promises favourable economies of production.

## BULGARIA

### Nitrogen Complex at Stara Zagora

A new nitrogen complex has been designed and will be partially financed by the U.S.S.R. for Bulgaria. The complex will be located at Stara Zagora in the eastern section of the Marica Coalfield, to the north of Dimitrovgrad and north-east of Plovdiv. The plant is expected to be in production in 1963, when it should produce 300,000 tonnes a year of ammonium nitrate and by 1966 500,000 tonnes a year, and 20,000 tonnes urea. Ammonia production will be based on the Marica lignite

Capital expenditure at the Stara Zagora works is estimated $US 185 million of which the U.S.S.R. has guaranteed a credit of approximately $US 52 million as well as providing process know-how and the greater part of technical equipment. At present nitrogen is produced in Bulgaria only at the Stalin Chemical Combine at Dimitrovgrad. In 1958 this plant produced 142,260 tonnes of nitrogen fertilizers based on gasification of brown coal from the Marica coalfield. In addition to the main ammonia synthesis units, there are plants for production of nitric acid, ammonium nitrate, sodium nitrate, ammonium sulphate, urea and sulphuric acid. Ammonium nitrate is the principal product and part of the output is exported; urea is also exported. Ammonium sulphate production is small.

Capacity of the Stalin Combine is known to have been 40,000 tonnes N in 1957 but is to be increased to 100,000 tonnes in the coming years. By 1962, nitrogen fertilizer output from Dimitrovgrad works alone is expected to be 330,000 tonnes and when the Stara Zagora combine comes into operation, output is expected to reach 1.6 million tonnes N in 1965.

Bulgarian nitrogen fertilizer consumption was 47,000 tonnes (N) in 1958/59 of which only 25,000 tonnes was home-produced.

## CZECHOSLOVAKIA

### Rise in Czech N Fertilizer Production

In 1959 132,940 tonnes of synthetic fertilizers were produced in Czechoslovakia compared with only 108,077 tonnes in 1958. Leading nitrogen products were 25,711 (25,400 in 1958) tonnes of ammonium sulphate, 10,109 (10,374) tonnes of calcium nitrate, 85,221 (66,466) tonnes of Ostrava nitrate, 7,328 (7,512) tonnes of crude calcium cyanamide, 75 (78) tonnes of ammonium nitrate and 4,404 (2,207) tonnes of ammonia used for fertilizer purposes.

At Luvosice, a plant has recently gone into operation for production of calcium ammonium nitrate. A striking feature of the development of Czechoslovakia's nitrogenous fertilizer economy, however, is the increasing use of ammonia liquor for direct application

**Czech Fertilizer Production 1948-1959**

(tonnes)

| | 1948 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 |
|---|---|---|---|---|---|---|---|
| **Nitrogenous fertilizers (N)** | **22,524** | **38,780** | **60,402** | **64,495** | **74,403** | **108,077** | **132,940** |
| i.e. | | | | | | | |
| Ammonium sulphate (N) | 4,693 | 17,967 | 21,083 | 22,716 | 25,712 | 25,440 | 25,711 |
| Calcium nitrate (N) | 7,965 | 8,620 | 8,854 | 8,832 | 8,754 | 10,374 | 10,109 |
| Ostrava nitrate (N) | 4,737 | 6,703 | 21,107 | 22,976 | 29,944 | 66,466 | 85,221 |
| Calcium cyanamide (N) | 5,014 | 5,490 | 6,363 | 6,885 | 5,831 | 7,512 | 7,328 |
| Ammonium nitrate (N) | — | — | 2,995 | 3,686 | 3,844 | 78 | 75 |
| Ammonia used for fertilizer purposes | — | — | — | — | 318 | 2,207 | 4,404 |

# Important Construction Orders for Union Chimique Belge

A HIGH level activity in all sectors is reported by Union Chimique Belge, Brussels, in its annual report for 1959-60. Whereas production capacities at its various units have been fully utilised, adverse economic conditions resulted in profitability being lower than had been hoped. Nitrogen fertilizer export markets have failed to improve and prices have continued to decline.

As was indicated in the previous year's annual report, U.C.B. no longer operates the plant at Houdeng-Goegnies following the sale of its share in Fabrication des Engrais Azotes, S.A.F.E.A. In consequence, nitrogen fertilizers now represent only 14.6% of U.C.B.'s total turnover compared with 21% before. The company is concentrating all its nitrogen activities at the Zandvoorde plant and is modernising the plant installation with a view to reducing costs.

## Chemical Products Division

Turnover of this division, excluding the activities of Houdeng-Goegnies works, has risen slightly compared with the previous year. Tonnage has increased substantially compared with the value of the output mainly as the result of the low prices for nitrogenous fertilizers.

As part of the modernisation programme for nitrogen fertilizers production at Zandvoorde which was started several years ago, U.C.B. has now modernised the nitrochalk plant with the installation of a new nitric acid plant, a new nitrating and a new granulating production unit, together with associated storage and handling and packaging facilities. Capacity for phosphoric acid and polyphosphates production is also being expanded.

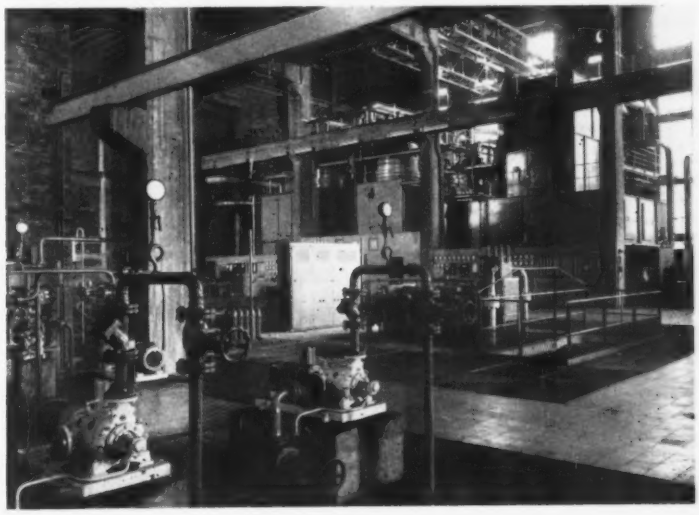
An important innovation at the works is the installation of a completely automatic handling system which permits transport of fertilizers destined for export from store direct to barge.

Special type polyester resins and acrylic emulsions and solutions have been studied by U.C.B. Overseas expansions are being pursued in the acrylic field in Australia and Great Britain.

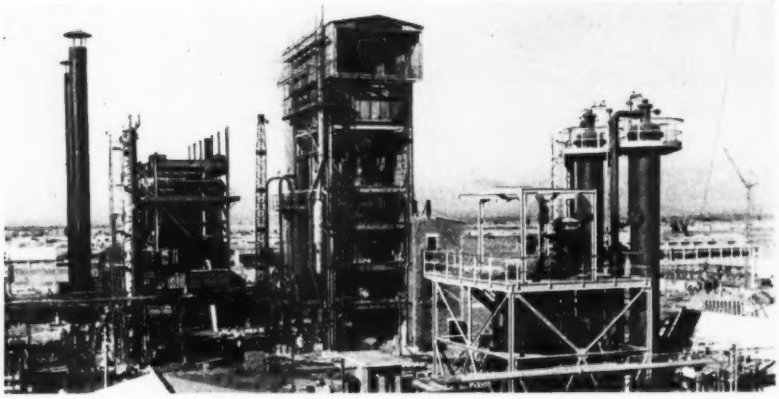
## Construction Activities

The large programme of plant constructions which U.C.B. has on hand will keep the plant projects and construction division of U.C.B. fully employed. Of the many interesting projects in hand the following are of interest.

With a view to utilising its coal resources, Société des Charbons, of Lukuga in the Belgian Congo, has ordered U.C.B. to undertake an economic and technical study for a nitrogenous fertilizer factory, to be set up near the coking plant at Greinerville. Since the end of the financial year, the U.S.S.R. has ordered



**New synthetic ammonia plant at U.C.B.'s Zandvoorde works**



**The new fertilizer plant for Pakistan Industrial Development Corporation at Daud Khel (Iskandarabad) which has been designed and engineered by Union Chimique Belge**

from U.C.B. a tripolyphosphate plant of 30,000 tonnes a year capacity to be set up in Russia; it will use the U.C.B.-Saint-Gobain process.

At the request of the Pakistan Industrial Development Corporation, two U.C.B. experts are to supervise the start-up of synthetic ammonia and ammonium sulphate plants at Daud Khel which have been constructed by U.C.B.

# Decline in Nitrogen Export Markets Affected Osterreichische Stickstoffwerke AG.

As a result of international competition in the chemical industry and particularly in the nitrogen market, price levels of Osterreichische Stickstoffwerke AG. of Linz, Austria, principal products declined, especially in export markets during the financial year 1959. The company's export turnover also declined slightly and the increase of 19% in domestic sales did not fully make up for this.

Plants operated near capacity, and production further increased by 8.5% to 1,075,000 tonnes of all products. Profits in 1959 totalled 17.7 million schillings, 10% less than in the preceding year. Nitrogen production* increased 7%, including 76,400 tonnes ammonium sulphate and ammonium nitrate, technical nitrogen and urea in complex fertilizers.

Since resumption of operations after the war up to 8 June 1959 a total of 6 million tonnes ammonium sulphate and lime ammonium nitrate have been produced.

The decline in turnover of 2.8% compared with the preceding year was solely attributable to exports and was caused by changes in shipping schedules towards the end of the year in major export contracts.

Deliveries of nitrogenous fertilizer included 685,000 tonnes (1958: 593,000 tonnes) of which 198,000 tonnes (1958: 180,000 tonnes) were supplied to the domestic market. Of the balance shipped to export, destinations were as follows:—

| | 1958 | 1959 |
|---|---|---|
| Europe ... ... | 38% | 57% |
| Africa ... ... | 10% | 5% |
| Asia ... ... ... | 50% | 38% |
| America ... ... | 2% | less than 1% |

Principal markets in 1959 were: China, Hungary, Bulgaria, Yugoslavia, Korea, Egypt, Portugal, Greece, Cyprus, Ireland, Pakistan and India.

The company continued its intensive promotion work in export markets especially in India where, in co-operation with other European nitrogen manufacturers, they promoted the Kisan Khad scheme for lime ammonium nitrate. Other major activities of the company include the manufacture of sulphuric acid, superphosphate, cement, water softening agents, phthalic anhydride, pesticides and pharmaceuticals.

Of total investments in 1959 of schillings 98.9 million only minor amounts were assigned to the company's nitrogen plants where automatic control was introduced into the high pressure synthesis system.

Among the company's intensive research and development work, favourable results were reported on large-scale trials for the recovery of platinum catalyst in nitric acid manufacture. A licence for West Germany was issued.

The general tenor of operations improved after June when natural gas deliveries which previously had been limited, started to flow normally.

* It is estimated that total production of nitrogen was approximately 180,000 tons N.

# Disparity Between Internal Costs and Foreign Exchange Rates Affect Anglo-Lautaro and Chilean Nitrate Industry

*"Pressure of internal costs has now reached proportions which operations are unable to sustain, and the absence of any indication of relief in the near future constitutes a matter of grave concern for the company and the Chilean nitrate industry."*

**Harry F. Guggenheim**
**Chairman**
**Anglo-Lautaro Nitrate Company, Chile**

IF a serious deterioration of the position of Anglo-Lautaro Nitrate Company of Chile is to be avoided, substantial relief in the exchange situation must be forthcoming promptly. According to the chairman, Mr. Harry F. Guggenheim, "pressure of internal costs has now reached proportions which operations are unable to sustain, and the absence of any indication of relief in the near future constitutes a matter of grave concern for the company and the Chilean nitrate industry." No efforts have been spared over the years to ensure maintenance of operations "on an economically sound basis," and investment in plant modernisation and diversification during the past 10 years has amounted to U.S. $37.5 million.

## Reduction in Expenses

A drastic expense reduction has been put into effect, but none of the measures taken can ensure maintenance of an economically sound operation in the face of the basic disparity between internal costs and foreign exchange rates in Chile.

Anglo-Lautaro's construction programme is proceeding rapidly towards conclusion, but the directors have postponed the portion relating to the construction of five additional evaporation ponds and a new by-product plant. This, the report states, can be undertaken only if and when conditions affecting operations improve sufficiently to ensure an adequate return on the large investment in over-all plant facilities.

## Financial Situation

Net income fell from U.S. $3,168,601 to $1,908,648 for the year to 30 June 1960 and the dividend is reduced to 40 cents (70 cents in 1958/59) on the 'A' shares with corresponding pro rata amounts on the 'B' and 'C' shares.

# New Markets for Nitrogen Being Surveyed by L'Air Liquide

FAVOURABLE gas sales are reported by L'Air Liquide—Societe Anonyme pour l'Etude et l'Exploration des Procedes Georges Claude—for the year 1959. In particular, nitrogen gas sales have become even more important compared with the preceding year.

## New Application for Nitrogen

Efforts have been pursued by L'Air Liquide to develop the sales of nitrogen in gas or liquid form and new markets have been surveyed to discover those which were likely to prove interesting from the point of view of new applications for nitrogen in the industrial, biological and medical fields. The company has also continued to pursue its policy of carrying larger stocks and providing a better and more rapid distribution service to customers.

Activities in the European section have been satisfactory as have those in Libya, Sudan and Somalia. In Syria manufacture has been abandoned and an importer is now supplying customers.

The Swedish division has been working to the limit of its capacity and new extensions are projected. Results in fact have been higher than those of 1958.

In spite of the slowing down in general activity in Portugal, L'Air Liquide's sales have been maintained and in Spain sales of gases have continued to increase.

L'Air Liquide are participating in the Societe Algerienne de l'Azote (Azotal).

Profits for the year 1959 were 23.5 million N Fr. against 20.8 million N Fr. and the dividend has been raised to 6.50 N Fr. for older share issues and for later share issues to 3.25 N Fr.

# Statistical Appendix

## ITALY — Nitrogen Fertilizer Exports (Metric Tonnes)

| | 1957/58 | 1958/59 | 1959/60 |
|---|---|---|---|
| **AMMONIUM SULPHATE** | | | |
| Europe West | | | |
| Greece ... ... | 61,766 | 81,959 | 66,761 |
| Ireland ... ... | — | 507 | — |
| Malta ... ... | 316 | 446 | — |
| Portugal ... ... | 15,932 | — | — |
| Spain ... ... | — | — | 158,050 |
| Sub Totals ... | 78,014 | 82,912 | 224,811 |
| Middle East | | | |
| Libya ... ... | 1,296 | 595 | — |
| Jordan ... ... | 248 | 1,089 | — |
| Turkey ... ... | 21,323 | 53,673 | — |
| Sub Total ... | 22,867 | 54,357 | — |
| Asia | | | |
| China ... ... | 95,181 | 151,318 | 290,152 |
| India ... ... | 3,395 | 19,305 | 64,649 |
| Indonesia ... ... | — | 10,317 | — |
| Korea South ... | 61,803 | 30,038 | — |
| Pakistan ... ... | 34,108 | 9,578 | 21,550 |
| Tawain ... ... | 1,665 | 365 | — |
| Thailand ... ... | — | 54 | — |
| Veitnam ... ... | 248 | 983 | — |
| Sub Total ... | 196,400 | 229,958 | 376,351 |
| Africa | | | |
| Ethiopia ... ... | — | 40 | — |
| Nigeria ... ... | — | 20 | — |
| Sudan ... ... | — | 1,485 | — |
| Uganda ... ... | — | 457 | — |
| Sub Total ... | — | 2,002 | — |
| South America | | | |
| Argentina ... ... | 125 | 1,613 | — |
| Uruguay ... ... | 500 | 3,642 | — |
| Sub Total ... | 625 | 5,255 | — |
| **Total** ... ... | **298,821** | **396,808** | **662,823** |
| Others ... ... | 915 | 21,225 | 61,661 |
| **CALCIUM NITRATE** | | | |
| Europe | | | |
| Austria ... ... | — | 3,712 | — |
| Portugal ... ... | — | 1,181 | — |
| Spain ... ... | — | — | 5,540 |
| Yugoslavia ... | — | — | 1,238 |
| Sub Total ... | — | 4,893 | 6,778 |
| Middle East | | | |
| Egypt ... ... | — | — | 9,876 |
| **Total** ... ... | — | **4,893** | **16,881** |

| | 1957/58 | 1958/59 | 1959/60 |
|---|---|---|---|
| **AMMONIUM NITRATE** | | | |
| Europe West | | | |
| Cyprus ... ... | 2,180 | 3,731 | — |
| Austria ... ... | — | — | 3 |
| Portugal ... ... | 9,889 | 6,016 | — |
| Yugoslavia ... | 76,509 | 81,527 | 41,813 |
| United Kingdom ... | — | 553 | — |
| Greece ... ... | 5,015 | 35,117 | 58,169 |
| Sub Total ... | 93,593 | 126,944 | 99,985 |
| Europe East | | | |
| Bulgaria ... ... | — | 31,942 | 59,780 |
| Middle East | | | |
| Egypt ... ... | 23,836 | 117,596 | 103,234 |
| Ethiopia ... ... | — | 4 | — |
| Israel ... ... | — | 2,961 | — |
| Turkey ... ... | 1,553 | — | — |
| Iran ... ... | — | 3,596 | — |
| Sub Total ... | 25,389 | 124,147 | 103,234 |
| Asia | | | |
| China ... ... | 26,582 | 81,881 | 99,719 |
| India ... ... | — | 19 | — |
| Sub Total ... | 26,582 | 81,981 | 99,719 |
| Africa | | | |
| Africa East ... | — | 49 | — |
| Africa West ... | — | 29 | — |
| Mozambique ... | — | 196 | — |
| Sudan ... ... | 98 | 496 | — |
| Sub Total ... | 98 | 769 | — |
| North America | | | |
| U.S.A. ... ... | 17,960 | 3,175 | — |
| Australia ... ... | — | 402 | — |
| **Total** ... ... | **174,912** | **375,239** | **418,890** |
| Others ... ... | 11,290 | 5,869 | 56,172 |
| **UREA** | | | |
| Europe West | | | |
| France ... ... | 950 | 20 | — |
| Portugal ... ... | 294 | 120 | — |
| Sub Total ... | 1,244 | 140 | — |
| Asia | | | |
| China ... ... | 15,223 | 20,796 | 28,261 |
| India ... ... | 27,356 | 20,020 | 3,500 |
| Sub Total ... | 42,579 | 40,816 | 31,761 |
| Africa | | | |
| Sudan ... ... | — | 10,639 | 19,594 |
| Pacific Islands | | | |
| Philippines ... | — | 454 | — |
| Taiwan ... ... | 876 | 519 | — |
| Sub Total ... | 876 | 519 | — |
| South America | | | |
| Brazil ... ... | 1,643 | 506 | — |
| Colombia ... ... | 3,320 | 147 | — |
| Sub Total ... | 4,963 | 653 | — |
| **Total** ... ... | **50,003** | **56,114** | **53,698** |

## UNITED STATES — Nitrogen Fertilizer Exports (Short Tons)

| | | Anhydrous Ammonia | Ammonium Nitrate ($100\%$ $NH_4NO_3$) | | Ammonium Sulphate | | Nitric Acid ($100\%$ $HNO_3$) | Nitrogen Solutions ($100\%$ N) | Urea |
|---|---|---|---|---|---|---|---|---|---|
| | | Synthetic | Total Fertilizer | | Synthetic | By-product | | | |
| **1957** | **TOTAL** | **3,734,213** | **2,586,007** | **2,338,576** | **1,039,822** | **908,903** | **2,843,488** | **563,423** | **486,408** |
| **1958** | **TOTAL** | **3,831,420** | **2,524,057** | **2,272,905** | **1,097,750** | **640,852** | **2,601,915** | **631,903** | **530,098** |
| **1959** | **TOTAL*** | **4,509,713** | **2,864,938** | **2,582,938** | **1,099,437** | **588,441** | **3,073,852** | **821,912** | **631,504** |
| 1960 | January | 396,403 | 278,030 | 244,030 | 97,261 | 68,933 | 287,981 | 65,820 | 55,287 |
| | February | 381,279 | 263,572 | 231,884 | 93,595 | 66,563 | 280,709 | 65,907 | 50,922 |
| | March | 423,351 | 288,066 | 263,583 | 76,254 | 69,715 | 304,503 | 76,714 | 54,420 |
| | April | 416,220 | 255,396 | 231,135 | 68,683 | 63,929 | 275,457 | 104,960 | 47,667 |
| | May | 434,043 | 243,550 | 219,387 | 65,078 | 61,385 | 265,080 | 102,916 | 35,663 |
| | June | 407,907 | 208,670 | 185,816 | 52,195 | 49,645 | 234,603 | 60,629 | n.a. |
| | July | 382,292 | 218,896 | 200,293 | 58,914 | 37,695 | 242,362 | 44,414 | n.a. |
| | August | 380,339 | 236,459 | 215,881 | 63,906 | 44,197 | 255,250 | 50,697 | n.a. |
| | September | 363,601 | 259,279 | 233,440 | 70,961 | n.a. | 281,001 | 53,792 | n.a. |

* For monthly breakdown see Nitrogen, March 1960. n.a. Not available.

## BELGIUM — Production (Tonnes)

| | | Synthetic Ammonia | | By-product Ammonium Sulphate | Fixed Nitrogen for technical use | Compound Fertilizers | |
|---|---|---|---|---|---|---|---|
| | | Total N content | Fertilizer N content | N content | tons product | tons product | N content |
| 1958 | 1st quarter | 64,691 | 58,723 | 4,255 | 1,401 | 66,461 | 6,768 |
| | 2nd quarter | 68,079 | 63,747 | 4,871 | 1,734 | 56,199 | 6,236 |
| | 3rd quarter | 69,684 | 50,465 | 4,572 | 1,545 | 46,726 | 4,171 |
| | 4th quarter | 72,469 | 66,189 | 4,543 | 1,764 | 72,292 | 5,521 |
| **1958** | **TOTAL** | **274,923** | **239,124** | **18,241** | **6,444** | **241,678** | **22,696** |
| 1959 | 1st quarter | 75,593 | 68,812 | 3,688 | 1,644 | 70,866 | 5,305 |
| | 2nd quarter | 78,241 | 71,400 | 4,104 | 1,367 | 48,832 | 5,415 |
| | 3rd quarter | 70,223 | 61,282 | 4,081 | 3,294 | 47,862 | 4,812 |
| | 4th quarter | 79,579 | 69,626 | 4,349 | 3,247 | 70,021 | 5,963 |
| **1959** | **TOTAL** | **303,636** | **271,120** | **16,222** | **9,552** | **237,581** | **21,495** |
| 1960 | 1st quarter | 79,902 | 71,530 | 4,271 | 3,283 | 94,676 | 6,878 |
| | 2nd quarter | 83,995 | 75,470 | 4,116 | 2,413 | 49,179 | 5,826 |

## BELGIUM — Nitrogen Fertilizer Exports (Tonnes)

### AMMONIUM SULPHATE
(+ ammonium sulphate nitrate)

| | First half year | Second half year | |
|---|---|---|---|
| Angola | — | 680 | 680 |
| Argentina | 1,692 | — | 1,692 |
| Belgian Congo | 1,430 | 609 | 2,039 |
| Brazil | 11,894 | 12,796 | 24,690 |
| Canada | — | 1,738 | 1,738 |
| Canary Islands | 4,950 | 4,960 | 9,910 |
| Ceylon | — | 25,451 | 25,451 |
| China | 173,760 | 191,358 | 365,118 |
| Dominica | 1,801 | 3,300 | 5,101 |
| France | 5,886 | 5,338 | 11,224 |
| Germany (West) | — | 21 | 21 |
| Greece | 10,007 | — | 10,007 |
| Hong Kong | — | 500 | 500 |
| India | 12,714 | 32,345 | 45,059 |
| Indonesia | — | 10,028 | 10,028 |
| Iran | 2,000 | 100 | 2,100 |
| Ireland | 3,186 | 13,172 | 16,358 |
| Jamaica | — | 1,626 | 1,626 |
| Kenya and Uganda | 126 | 101 | 227 |
| Lebanon | — | 75 | 75 |
| Malaya | — | 5 | 5 |
| Mexico | 9,958 | — | 9,958 |
| Netherlands | 505 | — | 505 |
| New Zealand | 254 | 569 | 823 |
| Nigeria | — | 7 | 7 |
| Peru | 6,611 | 5,207 | 11,818 |
| Philippines | — | 2,000 | 2,000 |
| Portugal | 12,354 | 6,903 | 19,257 |
| Puerto Rica | 10,408 | 10,500 | 20,908 |
| Salvador | 1,842 | — | 1,842 |
| Spain | 32,550 | 24,900 | 57,450 |
| Syria | — | 297 | 297 |
| Tanganyika | — | 41 | 41 |
| Thailand | — | 800 | 800 |
| Trieste | — | 8,128 | 8,128 |
| Trinidad & Tobago | — | 152 | 152 |
| Union of South Africa | — | 20 | 20 |
| United Kingdom | 64,529 | 12,069 | 76,598 |
| Uruguay | — | 500 | 500 |
| Venezeula | 10,264 | 10,197 | 20,461 |
| **Total** | | | **765,095** |

### CALCIUM CYANAMIDE

| | | | |
|---|---|---|---|
| Belgium Congo | 175 | — | — |
| France | 1,080 | — | — |
| Netherlands | 3,093 | — | — |
| Others | 101 | — | — |
| **Total** | **4,449** | **—** | **—** |

### AMMONIUM NITRATE

| | First half year | Second half year | Total |
|---|---|---|---|
| Argentina | — | 580 | 580 |
| Australia | 102 | 356 | 458 |
| Austria | — | 10 | 10 |
| Belgian Congo | 81 | 92 | 173 |
| Brazil | — | 689 | 689 |
| Chile | — | 16 | 16 |
| China | 29,957 | 57,104 | 87,061 |
| Egypt | 7,100 | 56,500 | 63,600 |
| Ethiopia | — | 300 | 300 |
| Greece | — | 45 | 45 |
| Ireland | — | 1,192 | 1,192 |
| Israel | — | 5,000 | 5,000 |
| Jamaica | — | 2 | 2 |
| Kenya | — | 51 | 51 |
| Lebanon | — | 25 | 25 |
| Malaya | — | 8 | 8 |
| Netherlands | 40 | 15,185 | 15,225 |
| New Zealand | 405 | 411 | 816 |
| Nigeria | 18 | 1 | 19 |
| Peru | 250 | 1,300 | 1,550 |
| Portugal | 1,575 | 3,246 | 4,821 |
| Saudi Arabia | 395 | 1,800 | 2,195 |
| Syria | — | 200 | 200 |
| Trinidad & Tobago | 108 | 61 | 169 |
| Union of South Africa | 544 | 1,582 | 2,126 |
| United Kingdom | 8,659 | — | 8,659 |
| U.S.A. | — | 91 | 91 |
| Uruguay | 150 | 500 | 650 |
| **Total** | **49,804** | **145,929** | **195,733** |

### AMMONIUM PHOSPHATE

| | | | |
|---|---|---|---|
| Greece | 17,371 | — | — |
| Indonesia | 5,449 | — | — |
| Iran | 1,000 | — | — |
| Mexico | 1,000 | — | — |
| Netherlands | 4,000 | — | — |
| United Kingdom | 5,617 | — | — |
| Uruguay | 695 | — | — |
| Others | 3,899 | — | — |
| **Total** | **39,031** | | |

## EXPORTS FROM WESTERN EUROPE INTO EASTERN EUROPE (Fertilizers c.i.f. $) '000 $

| | Poland | Rumania | U.S.S.R. | Hungary | E.Germany | Czechoslovakia | Bulgaria | Total |
|---|---|---|---|---|---|---|---|---|
| **Austria** | | | | | | | | |
| 1958 | 100 | 200 | 100 | 2,300 | 200 | 600 | 100 | 3,600 |
| 1959 | | | | | | | | |
| **Bel.-Lux.** | | | | | | | | |
| 1958 | 1,600 | | | 400 | 1,400 | | | 3,000 |
| 1959 | | | | 400 | 1,000 | | | 1,400 |
| **France** | | | | | | | | |
| 1958 | | | | | | | | |
| 1959 | | | | | 100 | | | 100 |
| **W. Germany** | | | | | | | | |
| 1958 | | | | 100 | | | | 100 |
| 1959 | | | | 900 | | | 3,200 | 4,100 |
| **Italy** | | | | | | | | |
| 1958 | | | | | | | | |
| 1959 | | | | 600 | | | 4,500 | 5,100 |
| **Sweden** | | | | | | | | |
| 1958 | | | | | 200 | | | 200 |
| 1959 | | | | | 300 | | | 300 |

## EXPORTS FROM EASTERN EUROPE INTO WESTERN EUROPE (Fertilizers c.i.f. $) '000 $

| | Austria | Bel.-Lux. | Denmark | Finland | W.Germany | Greece | Iceland | Ireland |
|---|---|---|---|---|---|---|---|---|
| **E. Germany** | | | | | | | | |
| 1958 | 3,400 | 1,600 | 2,900 | 900 | | 1,100 | 200 | 1,400 |
| 1959 | 3,500 | 1,800 | 3,000 | 1,700 | | 200 | 200 | 1,300 |
| **Hungary** | | | | | | | | |
| 1958 | 1,100 | 100 | | | | | | |
| 1959 | 1,000 | | | | | 200 | | |
| **Poland** | | | | | | | | |
| 1958 | | 200 | | | | 800 | | |
| 1959 | | 400 | 100 | | | 1,900 | | 300 |
| **U.S.S.R.** | | | | | | | | |
| 1958 | | 1,600 | 700 | 4,700 | 2,100 | 1,400 | | 200 |
| 1959 | | 1,500 | 800 | 4,700 | 3,100 | 800 | | 100 |

| | Italy | Netherlands | Norway | Sweden | Switzerland | U. Kingdom | Yugoslavia | Total |
|---|---|---|---|---|---|---|---|---|
| **E. Germany** | | | | | | | | |
| 1958 | 500 | 2,100 | 600 | 2,800 | | 4,600 | 6,500 | 28,600 |
| 1959 | 400 | 2,300 | 900 | 2,800 | 100 | 5,700 | 5,000 | 28,900 |
| **Hungary** | | | | | | | | |
| 1958 | | | | | | | 300 | 1,700° |
| 1959 | | | | | | | 700 | 1,700 |
| **Poland** | | | | | | | | |
| 1958 | | 100 | 100 | 100 | | | 3,600 | 4,700 |
| 1959 | | | 100 | 100 | | 300 | 1,300 | 4,500 |
| **U.S.S.R.** | | | | | | | | |
| 1958 | 200 | 2,200 | 1,600 | 1,400 | | 200 | 3,100 | 19,400 |
| 1959 | 1,000 | 2,300 | 1,400 | 800 | | 700 | 1,400 | 18,600 |

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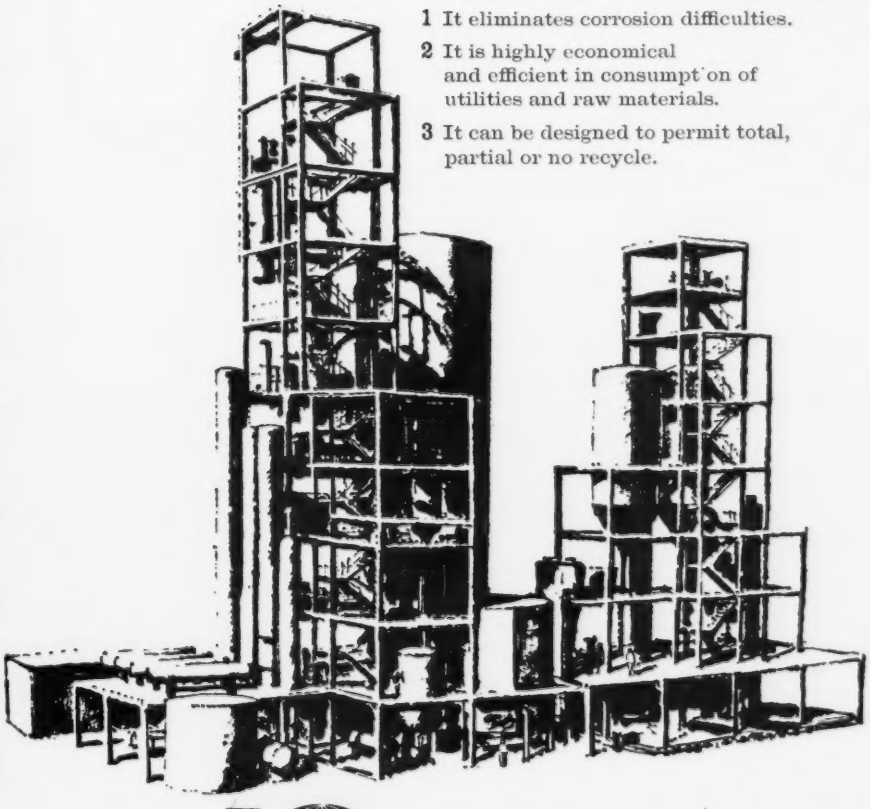

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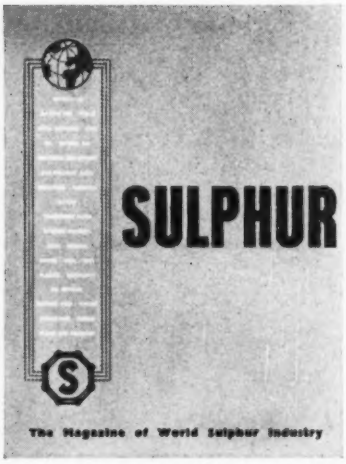


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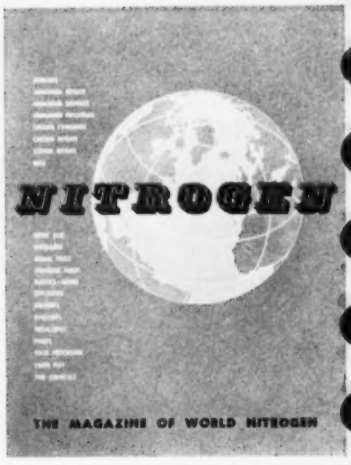


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